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This study investigated selected transformation abilities predicted by Guilford's structure-of-intellect model of intelligence and related those abilities to aspects of academic learning. To demonstrate the 16 hypothesized unique abilities, 46 aptitude tests were designed and administered to 197 high school students. The score variables were factor analyzed. Of the 17 factors which were clearly demonstrated, 10 were in the transformation category. Additional aptitude factors (6) provided reference vectors within which the transformation factors could be unambiguously identified. A studying-and-remembering task which measured academic learning was found to be significantly related to factors of verbal comprehension, memory for meaningful changes, and four other factors of production and evaluation of transformations and classes. This finding was interpreted as confirming the hypothesis that learning is often a process of redefining and reinterpreting known information--a hypothesis that goes well beyond historical associationistic theories. [Not available in hard copy due to marginal legibility of original document] (Author/NS).

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December, 1968

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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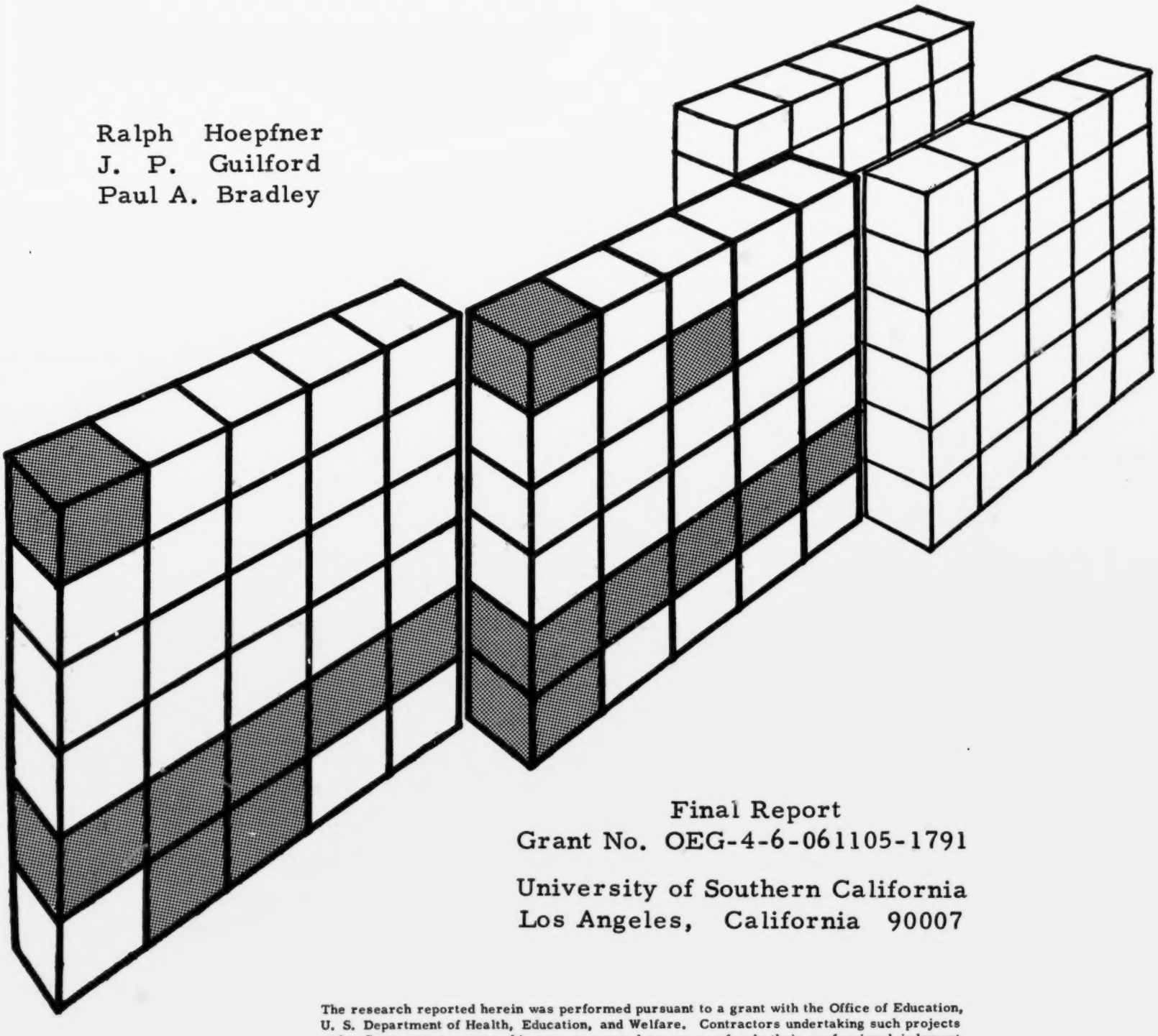

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SUMMARY

This study was designed to investigate selected transformation abilities predicted by Guilford's SI model of intelligence and to relate those abilities to aspects of academic learning.

To demonstrate the 16 hypothesized unique abilities, 46 aptitude tests were designed or revised to represent the factors. A studying-and-remembering task was developed to serve as a criterion of academic learning. The 47 measures were administered to 197 high-school students and the score variables were factor-analyzed.

Seventeen factors were clearly demonstrated, of which 10 were in the transformation category. These 10 factors were of the cognition, memory, divergent-production, convergent-production, and evaluation of symbolic and semantic transformations. Six additional aptitude factors provided reference vectors within which the transformation factors could be unambiguously identified.

Scores on the measure of academic learning were found to be significantly related to factors of verbal comprehension (CMU), memory for meaningful changes (MMT), and four other factors of production and evaluation of transformations and classes. This finding was interpreted as confirming the hypothesis that learning is often a process of redefining and reinterpreting known information -- a hypothesis that goes well beyond historical associationistic theories.

IDENTIFICATION OF TRANSFORMATION ABILITIES IN THE STRUCTURE OF INTELLECT MODEL

INTRODUCTION

The two major objectives of this study were to continue the investigation of abilities predicted by the structure-of-intellect (SI) model, particularly those unique abilities dealing with the intellectual process of changing, revising, or redefining information, and to investigate the involvement of those transformation abilities in a significant aspect of academic learning.

THEORETICAL BACKGROUND

Definition of the Transformation Factors

Of the 120 intellectual abilities hypothesized by the SI model (Guilford, 1959), 84 could be regarded as having been confirmed or newly demonstrated by experimental applications of factor analysis at the Aptitudes Research Project at the University of Southern California, at the initiation of this study.

The SI model is a logical classification of the known and expected primary intellectual abilities. The intellectual abilities differ on three parameters, making the SI model a 3-dimensional affair. The basic dimension of the model is that of content, on which there are four, broad, substantive, categories of information, each category being qualitatively different. The 84 known abilities are classified in the content categories of figural, symbolic, semantic and behavioral information.

The known abilities require a secondary distinction, that of operation or intellectual process that the individual "does" to information. The operations are of five kinds: cognition, memory, divergent production, convergent production, and evaluation. The third parameter needed to specify uniquely each ability is that of product. A product is a form in which information can occur or a basic way in which information is dealt with psychologically. The six kinds of product are: units, classes, relations, systems, transformations, and implications.

The three-way classification of the intellectual abilities means that each one can be uniquely identified by a single conjunction of three parameter categories-- operation, content, and product. It also means that by virtue of common parameter categories, abilities are parallel. Parallel abilities also mean that the kinds of tests needed to measure them in individuals have some parallel properties. When the organization of known factors along the lines of the SI model was first attempted, only about 40 factors had been recognized. The finding of new factors helped to refine the model and each new factor has fitted logically into one of its cells.

The model hypothesizes a total of 20 abilities dealing with transformations, of which 13 had some empirical support prior to this study. With only about two-thirds of the predicted transformation abilities known, there is still much to be done in determining whether transformation abilities exist as a full set of separate dimensions of intellectual functioning.

The status of the present knowledge regarding transformation abilities can best be shown by reference to the SI model, selecting the horizontal layer of cells representing those abilities, as in Table 1. Each column of the table represents one of the four general kinds of information and each row represents one of the five kinds of operation. The trigram in each cell stands for a unique conjunction of operation, content, and product. Initial letters are used except that M stands for "semantic" information and N stands for "convergent production." Thus, the trigram, MFT, in the first column and second row, stands for memory for figural transformations.

Table 1

The Transformation Matrix of the Structure-of-Intellect Model

	Figural	Symbolic	Semantic	Behavioral
Cognition	CFT X	CST I	CMT X	CBT X
Memory	MFT O	MST X	MMT X	MBT
Divergent Production	DFT X	DST I	DMT X	DBT O
Convergent Production	NFT X	NST X	NMT X	NBT
Evaluation	EFT X	EST X	EMT X	EBT

Note: An X indicates an ability already identified as a factor. An I indicates an ability under special investigation in this study. An O indicates an ability simultaneously under investigation in another study.

The Xs in some cells indicate transformation abilities that had been previously demonstrated. There are three such abilities in the area of cognition, two for memory, two for divergent production, three for convergent production, and three for evaluation. The letters "I" and "O" indicate abilities simultaneously under investigation at USC, in this study or in other studies, respectively. New information was desired concerning some transformation abilities already demonstrated, and some better tests were needed.

The chief practical limitation imposed upon a single factor-analytic study is the testing time available for the test battery to be analyzed. Experience has shown that it is reasonable to expect about eight hours of testing time. With an average of four tests for each new hypothesized factor and with more than half the tests in the battery being marker tests for reference factors, this research was limited as to the number of new factors that could be adequately investigated.

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[1] This study is one of a series conducted by the Aptitudes Research Project at the University of Southern California. Among the authors, Hoepfner and Guilford were Responsible Investigators and Bradley was Study Leader during the later stages of the study.

Since investigation of abilities in the figural column of Table 1 was a major outcome of the recent study by Hoffman, et al., (1968), and since the relevance of figural abilities to measures of scholastic learning and achievement are not usually great, it was decided to exclude further consideration of the figural factors from this research. Investigations of the behavioral column have been made only recently and information regarding the effectiveness of tests for those factors is still cumulating. With this uncertainty in mind, the behavioral factors were also excluded from further consideration.

The efforts of this study were confined to the middle two columns of Table 1, the factors involving symbolic and semantic content. Tests designed to measure symbolic content have items composed of letters, numbers, or other conventional symbols, including words, where meanings of words are not relevant to test performance. Semantic tests involve verbally meaningful information, and ideas must be handled.

The unknown factors of CST and DST received greatest attention, for identifying them through tests designed for them would bring the number of known SI factors to 86, and further strengthen the status of transformations as an independent product of intellectual functioning. The thought has often been expressed that transformations are less like a product and more like an operation. One redefines, one revises information, and one reinterprets. Attempts to alter the SI model by assigning transformations to the operation parameter only resulted in a great deal of confusion; some hypothesized factors are difficult to conceptualize, and other, known factors have no place in the model. Clearly, the more transformation factors that are firmly placed within the present model, the more difficult alternative arrangements of abilities in the model become, and the more confidence there is that transformation has been correctly treated as a product. After all, changes can be recognized as items of information, as are events.

Factors CMT, NMT, EMT, and EST were not as securely supported as should be desired, so they also were given special attention in this study. For these factors, new tests were developed, with expectations of higher loadings on their respective factors and also greater univocality, thereby supporting their factors more strongly.

Reference factors outside the transformations category were also included in order to account for possible extra variances in tests intended for transformation factors, thereby making it possible to isolate the transformation factors more clearly. The reference factors represented were CSU, CMU, CMI, MSI, DSI, and DMC.

History of Transformation Factors

The only direct precedents for this research are in the studies originating from the Aptitudes Research Project. Transformation abilities were found as factors incidental to investigations aimed at other concepts-- reasoning, creative thinking, planning, and evaluation. More recently the studies have been on other categories, usually found in vertical columns of the SI model, such as semantic-evaluation abilities or symbolic-memory abilities, as examples. One previous study, like the present one, concentrated on a horizontal slab of the model, an analysis of abilities pertaining to the product of classes (Dunham, et al., 1966).

Although the concept of "transformation" is a new one in psychology, because of its membership in the category of flexibility-rigidity traits, it has some indirect kinships to numerous, not-too-systematic studies in the past, inspired for all sorts of reasons. As mentioned earlier, the kind of flexibility concerned in this investigation is involved with thinking operations, and has its closer kinships with problems of insight, intuition, and redefinition in problem solving.

By 1957, when Guilford proposed a preliminary model for the classification of known intellectual aptitudes, seven factors now known to involve the transformation product were included, although not all under the name of transformations. In the cognition area, penetration, the ability to see beyond the immediate and obvious (Kettner, et al., 1959), was thought to be possibly different from the conceptual-foresight factor (Berger, et al., 1957). The suspicion was, however, that the former factor, CMT, and the latter, CMI, had not been successfully differentiated from each other.

Attempts to separate the two factors followed immediately. Marks et al., (1959) found conceptual foresight was represented by Pertinent Questions, Alternate Methods, and Apparatus Test, while penetration was represented by Social Institutions, Similarities, Social Situations, Competitive Planning, and Seeing Problems. In terms of Marks' original hypotheses, the demonstration of distinctness between the two factors was a failure; both factors were defined largely by tests hypothesized for other factors, and only 12 of 21 tests were in the hyperplanes of either or both factors. No further attempts were made at differentiation until 1964, when Nihira, et al., (1964) once again found overlap among tests for the two factors, even though CMT was to emerge as a separate factor and CMI was more strongly indicated by the merger of tests of the former EMI factor with CMI tests. By 1960, Guilford and Merrifield hypothesized, on logical grounds, that a differentiation of CMT from CMI would have heuristic value.

The CMI-CMT confusion was not completely resolved by rerotations of the factor matrices by more powerful methods. Accordingly, both factors were to be well represented in this analysis, with new tests of CMT that follow better from its SI specifications, in order to determine more precisely the differences between them.

Within the convergent-production operation category, the factors previously known as structural redefinition (NST) (Frick, et al., 1959), and conceptual redefinition (NMT) (Hertzka, et al., 1954; Kettner, et al., 1959) were thought to be unique, but the evidence was weak for the former factor. It was clear, however, that both factors involved redefinitions, changes, or reinterpretations.

The symbolic factor, NST, has since been identified several times (Guilford, et al., 1961; Petersen, et al., 1963; and Hoepfner, et al., 1964). In all three cases the factor failed to emerge with great clarity. Both the 1961 and the 1964 studies found some confusion of tests for CSU and NST, while Petersen, et al., found NST and NSI involved in the same test in one sample but not in another. The semantic parallel, NMT, was factorially confirmed only weakly when Nihira, et al., (1964) found only one strong test for it, but it was weakly supported also by a test developed for EMR. In terms of clarifying the convergent-production, transformation factors, the goal was two-fold: to make clear differentiations between the NST and CSU factors, and to make sure that NMT is clearly distinct from its parallel cognition factor, CMT.

The originality factor (DMT), was identified several times before 1957, but not always with ideal clarity. Sometimes the DMT factor was defined with the help of a large variety of tests that were stronger for other factors, especially with tests of neighboring semantic, divergent-production factors. For a time, the originality factor was thought possibly to have motivational or temperamental involvement. Merrifield, et al., (1961), demonstrated that the non-aptitude involvement in DMT scores was minimal, and more recent investigations, e.g. Guilford and Hoepfner, (1966) have unambiguously shown that tests of the DMT factor involve remote, unusual, or clever transformations of semantic information.

The remaining factor recognized in 1957 as possibly a transformation ability, was called the "judgment" factor. Judgment was found first in the Army Air Force research during World War II (Guilford and Lacey, 1947) and was sometimes found, sometimes not, in four early studies at the Aptitudes Research Project. Tests of the judgment ability, later placed into the EMT cell of the SI model, involved the selection between more-or-less plausible given solutions to practical problems. Since the solutions often involved looking at the problem in a new light (reinterpretation), judgment was thought to involve transformations. Working on this hypothesis, Nihira, et al., (1964) found little relationship between tests for the judgment factor and the factor EMT, and concluded that judgment did not have a single-factor place in the SI model.

When the factorial components of human intelligence were reorganized into a morphological model, it not only accounted for the known seven factors, but also predicted the thirteen additional factors that appear in Table 1. Factor-analytic investigations following 1960 were directed to isolating some of the hypothesized transformations factors and defining their natures. Among the experimental investigations of newly hypothesized factors was that by Nihira, et al., (1964) studying EMT, which was discussed above. The study of CBT by O'Sullivan, et al., (1964); and the finding of EFT by Hoffman, et al., (1968) are not of direct concern to us in this study.

The symbolic-transformation factor in the evaluation category, EST, was found by Hoepfner, et al., (1964) as a weakly supported, but clear, factor, its tests involving the judging of letter rearrangements and substitutions. No numerical tests had been designed for the EST factor, and no non-EST numerical tests correlated with it. The emergence of this factor on letter-word tests only might mean that it is confined to special content. It was therefore desirable to introduce a numerical test for EST in this study.

In a study of semantic-memory factors, Brown, et al., (1968), isolated MMT as the ability to remember word-meaning transformations — changes in word meanings, as in homonyms, puns, or riddles. The MMT factor in the Brown study had on it a large variety of tests loaded also on MMU, MMC, and MMS, the parallel factors for units, classes, and systems. In this study it was hypothesized that the involvement of the tests on the latter two factors may arise by the examinee's restructuring the materials to be retained, then by remembering the change, he could remember the class or system more easily.

The parallel symbolic-memory factor, MST, was found by Tenopyr, et al., (1966) peculiar to tasks of letter-substitutions and letter-placement changes. The leading test for the MST factor also led the list of tests defining CSU, the cognition of symbolic units, probably due to their common concern with correct spelling. In the study of this report, it was of interest to learn more of the breadth of influence of factor MST, and also to differentiate it more sharply from CSU.

Relation of Transformation Abilities to School Learning

The unique contribution of the transformation abilities to intellectual functioning is suggested most readily from their relation to flexibility and therefore to creative thinking. Of all the intellectual abilities that appear to contribute materially to creative thinking and problem solving, those pertaining to transformations are among the most important. In a special study of thinking flexibility (Frick, et al., 1959), it was shown that one of the transformation abilities, DFT, involves freedom from rigidity and from Gestaltbindung. It is the kind of ability that serves the problem solver when insight or intuition is needed, as in the Maier string problem. Another transformation ability, DMT, was first recognized as originality because of the obvious novelty of responses involved in its tests. It has been recognized, however, that originality is not restricted to semantic information, but applies to a class of flexibility factors or transformation abilities.

Allen, et al., (1960) found that top-grade research scientists do appreciate the importance of the product category of transformations in connection with their work. Four of the five factors they rated highest (among 28) with regard to importance in scientific creativity pertained to transformations, and none among the ten rated lowest did so. A general implication of the high status of transformation abilities is that they should be more generally recognized for their potential contributions to education.

It is increasingly apparent that the intellectual abilities and the concepts involved in the SI model are rich with possibilities in the direction of general-psychological theory. This is true, not only in connection with creative thinking and problem solving, but also in connection with the pervasive phenomenon of learning. There is the possibility that very much of what is called learning involves transformations of information; initial cognitions give way to new ones, and new ones come by way of revisions of old ones. It is common knowledge that traditional aptitude tests do a fair job of predicting status at the end of learning (all measures of achievement are primarily that) but that they predict rate of learning very poorly, if at all. "Transformation" is a change concept, and so is learning. The hypothesis remains to be tested whether scores in transformation tests can possibly do better in predicting rate-of-learning criteria. There is indirect evidence that this is the case, from the fact that measures of transformation abilities contribute substantially to the prediction of academic achievement in addition to that from traditional aptitude tests, which do not involve transformations (Cline, et al., 1962; Getzels and Jackson, 1962).

Kluever, (1968) found significant differences between groups of 30 normal readers and 30 disabled readers in the fourth grade on tests for MST and MMT. These differences, among those for 16 memory-factor comparisons, were the largest, and they were significant beyond the .01 level. Kluever also found that the MMT test score correlated significantly with a standard achievement-test score for reading comprehension for the students with reading disabilities. In a multiple-discriminant function for normal versus disabled readers, MST was the best discriminator and MMT was second best when the function was determined by memory tests alone. When achievement variables and IQ sub-scores were allowed into the discriminant function, MST still entered the function, second in weight only to overall achievement level in reading--the variable upon which the groups were formed.

Because of the importance of learning in education, the comments just made regarding the possible relation of transformations to learning also apply in educational operations. Where an objective of education is to foster development of problem-solving skills, the relevance of transformations to problem solving becomes especially important. Examples of the roles of transformations in various courses are easy to find. In mathematics, the student who factors algebraic expressions or solves equations is dealing with transformations. The budding scientist, who revises his conceptions or his hypotheses as he is confronted with new information, is also involved with transformations. In the arts and in creative writing, transformations are the order of the day. In general, it may be said that at any place in the educational situation where the purpose is the assimilation of information with the goal of seeking new and different applications for the material or solving problems based upon the given information, transformation abilities are involved. In this study one of the primary objectives was to determine the unique contributions of the transformation abilities to a measure of academic learning. A test of retention of previously studied information was used as the criterion of learning.

In terms of relatively narrow intellectual-aptitude factors, school learning is a multifaceted affair. The student formally learns information of several kinds of content, some figural, but mostly semantic and symbolic. He also is exposed to the product categories in a varied course of instruction and is expected to develop skills in most of the operations, although his scholastic success is not measured as if that were the case.

The overriding characteristic of scholastic or academic learning is the comprehension of information through reading, and its retention so that it may be recalled to meet the demands of some task. It is also true that the task that demands the recall of the cognized and retained information is different from the situation in which the information was first cognized. Since education is based upon the premise that learned information may be generalized or transferred to new problem situations, academic learning was characterized by different conditions for mental "input" and "output."

Faced with the demands of a particular task, the student engages in a searching or scanning activity for relevant stored information that might bear upon a solution. Duncker (1945) has described this mental activity as that of using a search model. The results of the searching behavior are what Guilford has called "transfer recall" (1967); recalling stored information in response to new cues. The intellectual behavior resulting from such transfer recall is of a production type, divergent or convergent, and it is these behaviors that are dominant in almost all problem-solving activities.

Thus, transformations may play roles in the whole learning process that culminates in problem solving. Items of information may be cognized as transformations and retained in the memory store as such. These events pertain to functions CMT and MMT, where the content is semantic. Other products of information may be similarly stored, with different degrees of potential or readiness for transformation. The items of information needed to solve a problem may be produced (e.g., DMU or NMU) in their original forms, or, if they do not exactly fulfill the need, they may be transformed (DMT or NMT) sufficiently to make better fits to requirements. Judging the fits would involve the function EMT or EMU, depending on whether the emphasis is on the change or on the transform. That is, transformations may occur during cognition or during production. It can be questioned whether they can also occur during retention. Reports of instantaneous productions of solutions after periods of inactivity on the problem suggest that this may be the case.

HYPOTHESES, APTITUDE TESTS, AND THE LEARNING MEASURES

Sixteen factors predicted by the SI model comprised the major factor-analytic hypotheses of this

study. The factors included the ten selected factors of Table 1, plus six reference factors which it was thought important to isolate from the transformation factors. An additional factor of sex membership was included in the solution to account partially for any systematic sex differences in factor performances. Finally, the studying-and-remembering test was to be related to the factors identified in this study in order to yield a partial "profile" of the aptitudes relevant to such learning situations. Knowledge of additional relevant aptitudes in this area should make it possible to increase accuracy of prediction and also to improve student performance in typical school learning.

The Transformation Abilities and Their Tests

The transformation factors are all characterized by the involvement of some change or reinterpretation of the information in test items. Whether the items are line drawings, numerical expressions, groups of letters, or words conveying meaning, the common denominator of transformation tests is that some change must be cognized, memorized, produced, or evaluated.

The hypothesized transformation abilities will be considered first and the tests selected or designed for each ability will be briefly characterized. Further descriptions of all the tests in this study will be found in the Appendix, listed in alphabetical order.

Cognition Abilities

The historical-empiricist view of intellectual functioning, that nothing is in the intellect except that which has come to it through the senses, gives a necessarily primary position to the operation of cognition. Within the product category of transformations, it should follow that unless one can cognize, he cannot retain, produce, or evaluate them. While this rather basic, almost hierarchical, view of mental processing makes logical sense, it does not ease the job set before the psychologist who is developing cognition tests for transformation abilities. These tests must assess the individual's comprehension level, without involving any other operation differentially in the population. Unless that requirement is met, there is little likelihood of obtaining an independent set of cognition factors.

Cognition of Symbolic Transformations - CST. To measure the ability to recognize that a specific transformation of symbolic information has occured, tests for CST ask the examinee (E) to give unequivocal evidence that he does see the change. Such evidence is obtained when E can match one symbolic change to another, describe the change, or answer questions the answers to which are obtainable only upon recognizing the change. All three designs were employed in tests for CST.

In Finding Letter Transformations E is asked to describe the change occuring between the two members of a pair of words, one member spelled correctly, the other not. The verbal description of the changes does not demand much in the way of naming ability, as any reasonable description of the change is acceptable.

Reading Backwards presents E with simple statements that are printed completely backward (words in reverse order, also letters within words). E is then to answer the questions asked or to do what the statements, thus printed, instruct. Since the statements are of a very low verbal-comprehension level, E is expected to read them and respond quickly. Performance on this test might appear to reflect ability to cognize symbols (in word form), regardless of the complicating transformation imposed upon them; but from another point of view, each word must be recognized as a simple transformation in order for the statement to make sense. Answering the simple questions, like "How many apples in a dozen?" gives evidence that the words were successfully transformed back to their correct order.

In describing the intellectual process underlying performance on Reading Backwards, it might be said that instead of recognizing simple transformations, E must actually do the transforming (i.e., read backwards). If such is the case, then Reading Backwards might be expected to correlate with tests of the parallel convergent-production factor, NST. It was hypothesized, however, that due to the simple nature of the task, seeing the transformation would be sufficient for successful test performance. This hypothesis also served as the basis for the third CST test.

Reading Confused Words asks E to write what the confused words should be. The words are confused by spelling them as if their sounds were mixed, as in spoonerisms or "bloopers." The confusions are mostly in terms of transposed initial consonant sounds or transposed vowel sounds. The hypothesis was that E has to see how the words have been transformed before he can see the words intended.

The fourth test designed for CST was Seeing Letter Changes, in which E's detection of changes in the letters of pairs of simple words is evidenced by his matching the change to a similar change in another word pair in a short matching format. Each consonant or vowel change in this test is of a very simple nature, so that E can easily see a "generalized transformation" which subsumes the given change and then apply it to a similar change in one of the alternative pairs. The simple nature of the letter changes was thought essential to differentiate this test from Word Relations, a test for CSR, which has more complex changes so that relationships can be educed from the sets of word pairs. Seeing Letter Changes and Word Relations were not pretested against each other to ascertain whether the differentiation was obtainable, and for this reason one might still entertain the hypothesis that the former test has some CSR variance. This assumption would receive some indirect verification if the reliability-communality difference for this test were large in the present analysis, which does not include the CSR factor. A notable difference might be due to CSR variance in Seeing Letter Changes.

Cognition of Semantic Transformations - CMT. The ability to see potential changes of interpretations of objects and situations has previously been marked by Similarities, which also correlates with the DMR

factor, and by Social Institutions, which also correlates with the CMI factor, and which, in addition, may have some behavioral component. Because of the lack of univocality of these tests, it was decided to develop a new set of CMT tests that might correlate more highly and univocally with the CMT factor.

Cartoons presents a picture of a cartoon situation and E is to write an appropriate punch line that is unexpected or clever, indicates a reinterpretation of the situation, is a play on words, or is an understatement for the pictured situation. A previous version of Cartoons, originally designed as a test for originality and requiring two responses from E for each cartoon picture, was found to correlate with the DMT factor (Kettner, et al., 1959; Merrifield, et al., 1962).

It was hypothesized, however, that when E is to give only one response, which is scored whenever there is any indication that any of a wide variety of transformations has been seen, Cartoons would be more appropriate as a measure of CMT. In this way, E's response serves as an indication of whether or not he is capable of seeing a potential transformation of the meaning of the cartoon picture. Initial pretesting indicated that Cartoons correlated very low with tests of DMT.

In an attempt to purge DMR (associational-fluency) from the Similarities test, Seeing Different Meanings was developed as a radical adaptation. While Similarities asks for several ways in which two things are alike (involving the relation of similarity), Seeing Different Meanings asks for several different meanings (transformations) of the same given word thus eliminating the relational feature. This test may be said to measure definitional flexibility, one kind of skill that a successful writer or speaker might have to a great degree. While it may appear that the new test has ruled out involvement of relations, it may not have ruled out productive thinking. It seems not altogether unreasonable to expect that Seeing Different Meanings may have loadings on the DMC or DMT factors. Any indication of a reinterpretation of the given word, whether by definition or through idiomatic usage, was scored as recognition of a transformation of meanings.

In Seeing Puzzle Meanings, E is presented with a rebus-like puzzle which he is to translate into a meaningful phrase or sentence. The words of the phrase or sentence are presented by pictures of objects, single letters, or numbers, whose names resemble in sound the intended words. If E can make an adequate translation of the rebus, it is assumed that he understands the transformation or sees the transform. The question arises as to what is transformed, however. In responding to Seeing Puzzle Meanings, although the result of the transformation is semantic, the things transformed are not all semantic. The use of figures, numbers, and letters and the fact that translations are based upon the sounds of the names of the pictured objects, may introduce figural or symbolic variance into this test.

The same reservation, but not as strong, may be directed against another CMT test, Verbal Picture Translation, in which E translates verbal descriptions of pictures that are only remotely related to the meaning of the correct translation. For example, he may be asked what object is described by the statement "A lawn that jumps about," to which the answer should be "grasshopper." Because words are in both stimulus and the response, there is more expectation that semantic variance predominates in this test. Once again, in Verbal Picture Translation, the correct response effectively serves as an indicator that E sees the transformations, not that he can produce them.

Memory Abilities

Closely interacting with cognition in everyday mental functioning, memory abilities are involved in the retention or storage of information that has been cognized. To be useful, such stored information must be available to the organism for use upon demand. Memory abilities alone are involved when the information is available in the same form in which it was stored and in response to the same cues in connection with which it was learned. If the information is recalled in altered form or if different cues call up the information, the mental process is in one of the two production categories. The organism is then said to have produced the information from his memory store.

Twelve memory abilities have been systematically investigated in recent years (Brown, et al., 1968; Tenopyr, et al., 1966), resulting in considerable evidence that both semantic and symbolic information are differentially retained according to the distinctions of the product categories of the SI model. That is, while a person may be strong in his memory-span ability (MSS), he is not necessarily also strong in his memory for particular symbols, dates, or words (MSU). The factors isolated in the two studies were found to be defined by tests of the recall and the recognition type, implying that both test formats reflect the same underlying memorative dimensions. It should be pointed out, however, that while the first study found semantic-memory factors and the second found symbolic-memory factors, neither demonstrated that there was a clear semantic-symbolic distinction within the memory operation. Including the two memory factors in this study constitutes the second limited attempt at content differentiation within the memory operation. Dunham, et al., (1966) had demonstrated the clear separation of MSC and MMC.

Memory for Symbolic Transformations - MST. The unique ability applying to remembering rearrangements and regroupings of letters in words, found by Tenopyr, et al., (1966), was represented by three tests. Although Tenopyr had recommended that the MST factor should be demonstrated with additional kinds of transformation tests, particularly tests involving numbers, this study utilizes only adaptations of word tests.

Memory for Hidden Transformations asks E to note the way in which small words are embedded in sentences and later to indicate whether or not the same small word in a new sentence is identically composed. Since Tenopyr, et al., found this test

to be univocal for MST, with a reasonably high reliability and symetrical score distribution, it was not altered for this study.

In the test Memory for Misspelling, E is given a list of misspelled common words to study and is to recall later how the words were misspelled when given the words correctly spelled. Tenopyr, et al., found this test to have a larger loading on CSU than on MST. The reason, in retrospect, seems to be that the cognition of the misspelled words during the study time was not as easy as had been expected. E's difficulty in recognizing the word from just seeing it misspelled, was very likely due to his limitations in CSU, hence the CSU involvement in performance. In an attempt to eliminate the CSU variance from Memory for Misspelling, new words were selected for study that, when misspelled, stand far more obviously for one and only one correctly-spelled word. In this way, it was hoped that word-recognition variance might be minimized and Memory for Misspelling might be loaded univocally on MST.

Memory for Word Transformations presents, on the study page, groups of letters each divided to make two words. On the test page, the same groups of letters are presented, some divided as they were on the study page, others divided differently. E is to remember the one way in which the letters were divided previously. This test was not revised, since Tenopyr, et al., had found it to be a univocal measure of MST.

Memory for Semantic Transformations - MMT. Brown, et al., (1968) first demonstrated the MMT factor as the unique ability for remembering changes in meaning, or redefinitions. Tests of that MMT factor had considerable involvement with other semantic-memory and cognition factors, and for that reason some of the tests employed in the present analysis were altered to eliminate possible contamination by other factors.

Double Meanings presents E with pairs of sentences with the same word used in two different ways, underscored in each sentence. On the test page new sentence pairs are presented, some with the same meanings as the underscored study-page words, and some not. E is to remember whether the two underscored words on the test page have the same meanings as those on the study page. The early form of Double Meanings did not present sentence pairs on the test pages, but rather presented pairs of definitions. The lack of a clear-cut direct transformation of the information was suspected to be the cause of the MMC involvement this test displayed. Making the study-page and test-page stimuli direct transformations of each other (both presenting E with sentences) should eliminate other-factor complications.

The only test found to be univocally loaded on MMT in the Brown, et al., analysis was Homonyms. In this test, E studies pairs of sentences in which two homonyms, such as "write" and "right," are underscored. Given the meaning of one of the underscored homonyms on the test page, E is to indicate that he remembers the words by selecting the other member of the homonym pair. The product memorized in this test is the change in meaning of the studied homonym pairs.

Remembering Puns presents sentences with puns for E to study, with the pun words underscored. On the test page, in response to the pun word, E is to recall and then write the pun meaning; what the pun word should really have been. This test had a substantial loading on the verbal-comprehension factor in the Brown, et al., analysis, indicating that some of the puns were of a vocabulary level not easily understood by all Es. It was hypothesized that, with the academic level of Es being higher in this study than in the Brown, et al., study, CMU involvement would not be so great.

The preceding explanation of the factorial complexity of Remembering Puns is in terms of the limitations of the Es who perform on the test. While characteristics of the sample tested can affect the observed factor composition of tests, we should also inspect the tests themselves with great care to see whether any inherent shortcomings can account for the tests' factorial behaviors. In the case of Remembering Puns, it is interesting to speculate how an E would perform if he were given only the test page. What ability might be involved in correctly surmising what the pun word really should mean? If E were given only the word "MYNAH," and he understood that puns are based upon common word sounds, the response "minor" might result on the basis of a cognition ability; E cognizes another word with a very similar sound. Following this line of reasoning, a side loading on a cognition factor (CST or CMT) might not be unexpected for this test.

Divergent-Production Abilities

Once information has been cognized and stored by the organism, it must be retrievable under many different task conditions that require its usage. When the task is one that requires many alternative retained bits of information conforming to task specifications, the production of information is called divergent. In the transformation-product category, divergent-production abilities are more easily recognized as flexibility factors--abilities to produce alternative changes.

Divergent Production of Symbolic Transformations - DST. This study represents the first attempt to demonstrate the factorial existence of the hypothesized DST factor. In general, tests for this ability should emphasize the varied production of changes or alterations in symbolic information, such as that composed of numbers and letters.

The test, Hidden Word Production, employs the same kind of symbolic stiumli as Memory for Hidden Words (MST) and Camouflaged Words (NST), words hidden in the context of a phrase or sentence. In the DST test, E is to produce different phrase contexts in which specified words are hidden. Each context produced involves a transformation of the letters of the given word; they fit differently into the new context and are therefore redefined in terms of letter grouping.

Multiple Letter Changes employs word stimuli in a manner somewhat similar to that of the EST test,

Jumbled Words. For each given, relatively short word, E is to substitute two or three letters to make a number of different words. Although it is units that are produced, the production of the new words is done by transforming the given word. The restrictions that the number of letters substituted is specified and that the ordering of remaining letters of the given word must be maintained were designed to avoid variance in DSU, to channel E's processes toward flexibly revising words.

E's task is slightly different in Multiple Word Extractions, in which large words are presented from which E is to extract many different small words that maintain the consecutive letter order of components of the original words. No small-word extractions are to be exactly the same as syllables of the large words, but must break down given syllables. In this way, it was expected that symbolic fluency would be minimized, and transformations of words would be maximized.

Divergent Production of Semantic Transformations - DMT. Guilford (1967) describes the "originality" factor (DMT) as being measurable by three types of tests, to which responses are "unusual," "remote," and "clever." The demonstration of DMT in this analysis sought to verify the general finding that all three types of test are measures of the ability to produce varied reinterpretations of some specified idea. A new test for DMT that could be more objectively scored was also tried out.

A test that asks E to produce remotely connected answers as a measure of originality is Consequences, which presents E with an unusual situation and asks him to list many different consequences. Scoring of Consequences has usually proceded in two ways: scoring for obvious implications of the situation, for DMU, and for remote or distant connections, for DMT. The "remote" score is presumed to reflect E's ability to produce varied reinterpretations of the given situation, which a remotely associated response entails.

Plot Titles is a DMT test when scored for the number of "clever" responses. Any clever title to the given short story is likely to involve a reinterpretation of the story or its significance or to be a play on words; both types of responses entail semantic transformations.

Whoppers, a newly designed test for DMT, was hypothesized to measure DMT by restricting E's responses to objects in a specified situation. The objects are to be altered to make them somewhat fanciful, even fantastic, such as a green pig or a silk frying pan. Under the assumption that far-fetched lies and exaggerations are transformations, E is instructed to make up the extreme lies that one might expect from a compulsive liar as she visits various common places. This test is an adaptation of an earlier test called Impossibilities, which was found to correlate with the ideational-fluency factor, DMU. Its DMU loadings were explained as being due to the unusual freedom from restrictions upon the ideas to be generated. With the imposition of situation-relevant restrictions. and the necessity of revamping familiar objects in most unusual ways, the test should involve semantic transformations.

The lack of a test for the DMU factor in this study prevented determining whether this test actually minimized the DMU involvement found in its predecessor. The test differs in a basic respect from other DMT tests, in which the same object or idea is to be transformed in different ways. In Whoppers, E produces different objects that may exist in prescribed settings, each one transformed in only one way.

Convergent Production Abilities

While divergent production enters into the process of solving many problems, some problems, having uniquely correct or agreed-upon solutions, are not efficiently solved by a divergent strategy. The problem solver must converge directly upon the solution. The process of retrieving and perhaps synthesizing a correct solution in terms of task specification is called convergent production. Of all the operations in the SI model, this one has received the least empirical factorial confirmation, but the two transformations factors to be considered have been previously isolated. When one and only one kind of change in information is necessary in order to solve a problem, we may say that transformations must be convergently produced.

Convergent Production of Symbolic Transformations - NST. The ability to break up or destroy symbolic items of information, in order to produce new items, involves the factor NST. The ability has been factor-analytically demonstrated three times (Guilford, et al., 1961; Hoepfner, et al., 1964; Petersen, et al., 1963), but in two of the studies, there was considerable difficulty in separating NST from the CSU factor. This confusion between tests of the two symbolic factors is analogous to the state of affairs with respect to Thurstone's "figural-closure" factors, CFU and NFT, which also had representative tests in common.

Camouflaged Words is the only NST test employed in this analysis that has consistently not had CSU involvement. It was included to maintain historical continuity of the factor and also to increase the probability that the NST factor could be separated from CSU. In each item of Camouflaged Words E is given a sentence in which the name of a game or sport is hidden. E is to encircle the hidden word, indicating that he has penetrated the symbolic context and changed the functions of certain letters.

In the new test, Efficient Word Transformations, E is given a group of four words and is to overlap them to produce the one shortest large "word" that contains all four given words embedded in it, with letter orders maintained. The large word may not be real or meaningful. The resulting large word is a transform of the small words and the production is convergent, since only one such large word is maximally efficient, i.e., shortest. Seeing the potential letter overlap among the given words and planning to capitalize maximally on those overlaps probably involves some CSI ability, and it might be expected that

Efficient Word Transformations would have some CSI variance in common with a test like Word Patterns, CSI was not included in the analysis to make possible the evaluation of this hypothesis.

In Limited Word Revisions the task is to make a new word by rearranging all the letters in the given word to make the new word. The symbolic unit (word) must be transformed by rearrangement to arrive at a new unit. The given words were selected, and restrictive rules were imposed so that, in general, only one real word could result from the letter rearrangement of each given word. The stimuli and their transformations in Limited Word Revisions are exactly like those of Jumbled Words, a test for EST. Whether or not specific or format covariance between these two tests would confuse the NST-EST differentiation was an interesting side question.

Convergent Production of Semantic Transformations - NMT. The "redefinition" factor, NMT, defined as the ability to produce new uses for objects by tearing them or their parts out of their contexts and redefining them, has been demonstrated with moderate success in several analyses at USC. The goal of this new analysis was to obtain a stronger, more univocal test for the factor and to determine whether Guilford's suggestion (1967) to have E "break down" the objects into parts (as he must do in tests for NFT and NST) would ensure the strength of the factor. Another question to be answered in this research was whether NMT can be represented more generally by tests featuring words or ideas as well as objects, to which NMT tests have heretofore been limited. It was hoped that with a test that was not concerned with real objects in the battery, the factor could be given broader reference. That test was Daffynitions.

The task in Daffynitions is to redefine given words so that only the words' sounds remain relatively intact, while the meaning is altered. Redefining the word "dessert" so that it can be used in the sentence: "dessertainly is delicious," constitutes a drastic change in word meaning. While there is not one and only one "correct" redefinition, only one is requested in Daffynitions, and for this reason it was hypothesized that E would converge upon his product. There was reason to believe, however, that CMU or CMT abilities might be tapped by this test. E must produce a phrase or sentence in order to indicate his new meaning hence some possible CMU variance, and he must be able to see that each given word has such a transformation (CMT). With both CMU and CMT represented in the test battery, these hypotheses could be evaluated.

New Uses is an adaptation of the older Picture Gestalt that had been the most dependable and univocal NMT test in previous studies. The revision of Picture Gestalt not only brought the photographs of home interiors up to date, but also increased the number of items. At the same time, it limited the items to those necessitating the use of parts of pictured objects. In New Uses E is to take a part or a combination of parts of the pictured objects and to reinterpret them so that they may serve the given uses. Each object part must be redefined from its appropriate use, as determined by its structure or its non-functional characteristics, to a new use.

A second test utilizing objects as the stimuli to be transformed is Object Synthesis, in which E is given two objects and is to name a new object he could produce by combining them. The new object must be functional and must be made from both given objects. In combination, the simple given objects undergo transformations in their functions. This test, like the other two NMT tests, does not demand the production of unique or correct responses, but the appropriate, and hence acceptable, responses are limited in number, thus channelling E's productivity in a convergent direction.

Evaluation Abilities

In the typical problem-solving sequence, E is continually confronted with the need to evaluate. The most salient part that the evaluation operation plays is in the comparison of a tentative solution of the problem with the necessary criteria a solution must have. Where transformations are involved in the problem-solving process, whether in the cognition, memory, or production aspects, at some time there must be an evaluation of the transformations in terms of the goals. While it might seem that the transformations all result in new units and therefore there is need only to evaluate units, it seems as if individuals do not work that way. Demonstration of the existence of factors of evaluation of transformations implies that the problem solver compares not the final transformed unit, but rather the whole dynamic transformation against whatever logical criteria he holds.

Evaluation of Symbolic Transformations - EST. The ability to judge the adequacy of symbolic substitutions or reorderings, EST, was found rather weakly by Hoepfner, et al., (1964), primarily by two of the tests included again in the present study. It was hypothesized that the altering of the EST tests on the basis of the 1964 findings and the addition of another potential EST measure would result in the demonstration of a stronger dimension of EST.

In the test Decoding, E is to make comparisons between pairs of words as to which one, if encoded according to a given ambiguous code, could most easily be decoded. The notion of transformation's being evaluated suggested that E need not encode and then decode, but could reach a decision on the basis of the whole set of transforming operations. Decoding was not a univocal EST test in the Hoepfner, et al., analysis, having a large secondary loading on the ESC factor. In order to rid Decoding of other-factor involvement, all the items were revised so that the comparison process would not be so difficult.

The task in Judging Mathematical Expressions is to judge whether or not alternative algebraic expressions are equivalent to a given expression. The comparison in this test is to be made between the given expression and a symbolically transformed one. This test was hypothesized to be a measure of EST without a great conviction that the hypothesis would be

borne out. Since no other test for EST was developed, it was decided to use the mathematical test, even though pretest results indicated that all four mathematical tests in the battery intercorrelated very highly among themselves, probably reflecting level of achievement or attitude toward mathematical problems. With this knowledge, whenever non-mathematical tests were available to measure a factor, they were preferred. In this way, it was hoped to avoid the confusion that might be caused by the inclusion of a mathematics-achievement factor in the factor solution.

Jumbled Words was the third test employed to measure EST. In it E is to judge whether or not alternative words are exact rearrangements of the letters of the given words. Jumbled Words was univocal on EST in the Hoepfner, et al., analysis, but did not have a very high loading on that factor. With the inclusion of two new or improved tests for this factor, it was hypothesized that Jumbled Words would prove to be a stronger measure of its factor.

Evaluation of Semantic Transformations - EMT. The first systematic attempt to define the EMT factor was made in the 1964 study by Nihira, et al. The three tests designed for EMT loaded on CMU, EMU, or EMR, and failed to show covariation to indicate a unique dimension that could be called EMT. A subsequent rerotation of the factor axes (Hoepfner, et al., 1966) found that, as a singlet, Useful Changes could define a dimension interpreted as EMT. It was thought that since Useful Changes asks E both to produce a transformation and to evaluate it, the object of judgment was the transformation, not the transformed unit, as was characteristic of the other two tests designed for EMT.

The task in Judging Object Adaptations is to choose one of three alternative functions of a given object that is most unusual, ingenious, or clever. This test is similar to the previously successful EMT test, Useful Changes, except that E must only see the transformation that the given object must undergo, rather than potentially produce it. The criterion for comparison, standards of unusualness, ingeniousness, and cleverness, were hypothesized to be sufficiently objectively specifiable in the sample so that personal values would not determine E's responses.

Punch Line Comparisons presents E with a cartoon and several pairs of punch lines appropriate to the cartoon. Within each pair, E is to choose the one that is more humorous, unexpected, or clever. Although the comparisons E makes are basically of reinterpretations of the cartoon situations, the introduction of the criterion of humorousness introjects with it the possibility that subjective judgment will determine performance, making the test relatively unreliable and therefore, quite probably, not highly correlated with the EMT factor, or any other factor.

The test, Useful Changes, presents E with a task to be completed and three alternative objects with which the task might be performed. E is to choose one object that would perform the task most adequately. It was hypothesized that E must transform each object to the given use before he can judge which transformation would be most successful in terms of adequacy. Whether this injects some production variance into the task could be evaluated in the analysis.

The Reference Factors and Their Marker Tests

The reference factors included in this study were for those non-transformation abilities that were expected possibly to account for some of the covariances among the transformation tests. They were incorporated into the factor-analytic design to ensure that the experimental factors are indeed unique dimensions, and not merely some other known factors parading under new names.

Cognition of Symbolic Units - CSU. Because the NST factor has often failed to exhibit complete non-overlapping of tests with those of the CSU factor, and because the same outcome might hold for tests of the as-yet-unknown CST factor, CSU was represented by two tests known to yield a unique dimension representing the ability to recognize symbolic units, such as words (Hoepfner, et al., 1964; Tenopyr, et al., 1966). Correct Spelling asks E to recognize whether or not given words are spelled correctly and Disemvowelled Words asks E to recognize words whose vowels have been removed.

Cognition of Semantic Units - CMU. In the discussion of several of the semantic-transformation factors above, it was suggested that the verbal-comprehension (CMU) ability might be involved in test performance. Whenever the verbal items of a test present word-understanding challenges, the CMU factor can be expected to play a role in performance. Two tests that have marked a verbal-comprehension factor with great consistency in the past were utilized to mark this reference factor, thereby making it possible to account for word-understanding involvement in the remaining tests. Verbal Comprehension, a multiple-choice vocabulary test, and Word Completion, a completion test, which asks E to write definitions or synonyms for given words, were employed to determine CMU.

Cognition of Semantic Implications - CMI. Tests of the ability to anticipate or be sensitive to the needs or consequences of situations have historically been found related also to the CMT and the DMT factors. CMI-CMT test confusions (e.g., Nihira, et al., 1964) have probably been the result of CMT tests that are not independent of CMI, which comes into play during the process of redefinition. Such tests as Similarities and Social Institutions demand some foresight and sensitivity to consequences before meaningful transformations can be seen. The CMI-DMT confusion (e.g., see O'Sullivan, et al., 1965) appears to be more basic. DMT tests, such as Consequences, have often utilized the seeing of implications as an incidental process in original productivity. Seeing a consequence is an act of seeing an implication. Seeing the consequence is apparently less crucial for individual differences than is revising the nature of the situation in the Consequences test.

In order to determine a strong CMI factor that would emerge regardless of the pressures put upon it

by CMT and DMT tests, three tests that had long histories of loading on CMI were employed. Apparatus Test asks E to suggest two improvements in each of several common appliances in order to indicate that he is sensitive to potential inadequacies of the objects. New items were created for the Apparatus Test, giving appliances that would be more common knowledge for high-school students. The fact that E must write two different improvements suggests the possible involvement of divergent production, most likely ability DMI. A factor for DMI was not marked by tests in this analysis.

In Pertinent Questions, E is to write as many as four different questions that need to be considered in making everyday decisions. Once again, although sensitivity to implications of the situation is the essential process measured, the production of four different questions suggests divergent production. In the same vein, Seeing Problems asks E to state as many as three different problems that might be associated with each given, common object.

Memory for Symbolic Implications - MSI. The symbolic-implications-memory factor was a vital aptitude to consider, since it might account for some of the contributions to the intercorrelations among the few mathematics tests. Tenopyr, et al., (1966) found Number-Letter Association, which asks E to recall letters arbitrarily paired with numbers, to lead univocally on the MSI factor. After many years during which the numerical-facility factor has been regarded as a primary ability, Numerical-Operations has been found to be factorially complex, with MSI as its strongest component.

Divergent Production of Symbolic Implications - DSI. Gershon, et al., (1963) found a DSI factor that was defined by Symbol Elaboration and Limited Words, but it was pointed out that finding a doublet is not completely convincing as a demonstration of a new unique ability. To complicate the picture further, there was reason to suspect that the DSI tests have some DST variance. The connections between the given information and its implications could qualify as simple transformations. Three tests hypothesized to measure DSI were included in this study in order more firmly to demonstrate DSI and to show its independence from DST.

In Multiple Symbolic Implications, E is given three-step numerical operations and a given numerical answer. His task is to produce many different number combinations that will satisfy the operations and the answers. Although the interpretation that E is transforming the given answer with each new combination appears reasonable, it was thought more likely that E would engage in producing many logical symbolic implications leading to the given answers.

Symbol Elaboration, the test in which E is to make many correct equations from two given equations, was only slightly modified from its 1963 form, to use in this study. The new form of Limited Words, now called Word-Pair Revisions, was revised so as to present simpler word pairs than in the 1963 study, and pairs from which more new word pairs could be produced. This revision was designed to overcome the severe positive skew of score distributions in the 1963 study, which was due to the difficulty of generating new pairs. The difficulty was also suspected of having partially caused the extra factor loadings (on CSR, CMU, CSU, and CFC) for Limited Words in that analysis. It was of further interest in this study to test whether Word-Pair Revisions might correlate with CSU or NST, either outcome appearing to be likely on the basis of the test's characteristic task feature of producing new words from old ones.

Divergent Production of Semantic Classes - DMC. The final reference factor was included as a check to determine how the spontaneous-flexibility factor, DMC, might be related to tests of the transformation factors that also fall in the category of flexibility. The two tests selected to mark this factor were a new form of Alternate Uses, in which E lists as many as six different alternative, unusual uses for a given common object, and Multiple Grouping, in which E is to group and regroup a given list of words into as many different classes as possible.

The Learning Measures

A major objective of this study was to determine the extent to which the abilities for dealing with transformations may be related to learning in academic subjects and whether tests for transformation abilities might have predictive value in connection with criteria of school learning. The concern of this section is with the measures of school learning: what the definition of such learning should be, and how it should be measured.

The Nature of School Learning

The concept of "ability to learn," like that of intelligence, is a multi-faceted one. Attempts to uncover some unified dimension that might be called learning ability have almost uniformly failed. By considering various learning abilities, each specific to some particular type of information, recent investigators have discovered systematic and logically expectable relationships with certain aspects of intelligence. Ferguson (1954) hypothesized that learning is differentially affected by abilities by virtue of transfer; that relevant abilities are utilized in different learning tasks. Based upon Ferguson's hypothesis, studies by Stake (1961), Allison (1960), Duncanson (1964), and Dunham, et al., (1966), have demonstrated that with the appropriate measures of differential abilities, considerable variance in measures of achievement in learning tasks can be accounted for.

In a refinement of Ferguson's transfer theory Gagné (1968), proposed a model of new learning that depends primarily upon the combination of what was previously learned. In this manner, Gagné explains that complex principles are learned through the combination of previously learned simpler principles, which in turn, are formed from concepts derived from discriminations. Assessment of the stages of learning of an individual must therefore take into account the individual intellectual abilities and the number of subordinate learning entities (simple principles, concepts, etc.) that must still be learned. Each learning entity is unique, and is further assumed

to be dependent upon intellectual abilities, but the entities are also generalizable so that they can transfer to many learning situations.

The type of learning under consideration in the present study is not as uncommon as those that have indicated relationships to intellectual aptitudes in the above-mentioned, recent studies. School learning, nonetheless, does serve as a useful concept for heuristic purposes, even though specific sub-types of learning would almost certainly emerge from an intensive analysis. School learning, in the most common sense, is defined for this study to be the acquisition of information by reading. It is in this manner that most academic learning proceeds, especially in substantive courses.

Applying Ferguson's or Gagné's models to this definition of school learning would imply that a student's ability to learn given information depends upon information he has already learned that might transfer, and also upon his individual profile of intellectual aptitudes, which also apply by virtue of their general natures. If previously learned items of information can be presumed equivalent for all the students in a study, learning differences would be due primarily to student status on the relevant aptitudes.

Measuring School Learning

Final proficiency or overall scholastic achievement, as indicated by grades, was rejected as an index for various reasons. Such composites are very complex and therefore ambiguous, with irrelevant components and other sources of error. Measures of final status, as indicators of learning ability also overlook variations in starting proficiency. Measures of "gain," consume considerable time and they are also unsatisfactory due to their generally low reliabilities and their consequent failure to correlate with other variables.

Fredricksen, et al., (1947) have suggested, for use as a measure of learning ability, appropriate, miniature learning situations which duplicate many of the essential features of the learning that is to be studied or predicted. Measures obtained from miniature learning situations have been successfully employed in specific problem areas (Fleishman, 1966; Allison, 1960; Dunham, et al., 1966). The investigators concluded that such measures predict achievement in subsequent learning situations and also appear to be related to measures of human abilities. In measuring the generalized concept of "school learning," what is needed is "some factorially complex verbal learning task which will yield a valid measure of an individual's learning ability, and which will show a strong relationship to classroom learning" (Wardrop, 1967, p. 4). Utilizing programmed instruction techniques, Wardrop found that miniature situations did effectively predict gains in classroom performance.

The specific learning task selected for this study was in the nature of a reading-comprehension test, although not of the ordinary sort. In the typical learning situation, the student studies the information to be learned, and then, when the information is no longer present for reference, is quizzed upon what he has learned. In the learning test of this study, the quizzing for the learning measure, in the form of multiple-choice items, was given after the reading material had been removed. Thus, there should be a large amount of memory variance involved in the scores. But this is a realistic feature. The special interest would be in memory for semantic transformations. There would also be some possibility for variance in cognition and evaluation of semantic transformation, but little for either divergent or convergent production, in view of the multiple-choice form of items.

To control further for unwanted variances in the learning tasks, the reading material and quiz items were constructed of relatively common words. The minimizing of difficult vocabulary and the introduction of new terms was accomplished in order not to maximize the involvement of the CMU factor; a factor that is known to be involved in general word understanding. To control for previous learning, the reading selections were composed of specific content that should be relatively novel to the Es. Consultation of test reviews indicated that most tests of the reading-comprehension variety have a major shortcoming in their interest levels for most students. Accordingly, the three tests developed to assess school-learning ability dealt with the topics of proteins and starvation, psychedelic drugs, and stock-market trends. Dealing factually with lesser-known aspects of these subjects was expected to be of interest to the majority of high-school Es, regardless of sex or school level.

Each section of the Studying and Remembering test, to be administered on a different occasion during the testing sessions, was composed of two parts. The first part was a written essay of about 400 words, which was tersely written so that it would convey maximum information. On the second part, the study page, E was to answer ten four-choice items. On the basis of pretest analysis, only those items were retained that were answered correctly significantly more by a group that had studied the material previously than by a group that was given the test part only. In this way, scores on the test would not depend very much on E's long-term store of general information, but would be dependent, instead, upon his short-term retention of newly studied information. The scores on the three sections of Studying and Remembering were to be summed for each E to obtain a more content-fair estimate of this school-learning ability.

PROCEDURES

Test Development

Eighteen of the 47 aptitude and learning tests were newly constructed for this study on the basis of precepts suggested by the SI model, and 12 other tests were revised in attempts to increase reliabilities and factor univocalities. Seven pretest administrations were conducted to evaluate the new and revised tests.[2]

[2] We wish to thank Dr. Stephen W. Brown, Mr. Santosh Kumar, and Mrs. Sandi Wollenman for their assistance in test construction and pretesting during the early phases of this study.

Table 2

Means, Standard Deviations, Reliabilities, and Distributions of Scores

Name of Test and Code	Mean	Standard Deviation	Reliability[a]	Form of Distribution[b]
1. Alternate Uses DMC03D	20.62	3.80	.56[c]	0
2. Apparatus Test CMI03A	15.63	2.98	.65[c]	-
3. Camouflaged Words NST01A	10.48	2.93	.74	-
4. Cartoons CMT03A	7.96	2.26	.35	0
5. Consequences DMT03C	8.13	3.65	.53[c]	0
6. Correct Spelling CSU07A	45.96	7.95	.68	-
7. Daffynitions NMT04A	22.97	3.94	.73	0
8. Decoding EST01B	13.88	7.06	.79	0
9. Disemvowelled Words CSU04B	14.76	4.14	.75	0
10. Double Meanings MMT01B	20.96	9.84	.73[d]	0
11. Efficient Word Transformations NST04A	13.22	5.50	.83[d]	-
12. Finding Letter Transformations CST01A	34.78	3.78	.51[d]	-
13. Hidden Word Production DST01A	31.03	6.82	.84[d]	-
14. Homonyms MMT02B	14.32	3.95	.78[d]	-
15. Judging Mathematical Expressions EST04A	9.01	7.46	.75[d]	0
16. Judging Object Adaptations EMT06A	12.51	5.07	.52	0
17. Jumbled Words EST03A	46.37	5.61	.86	--[e]
18. Limited Word Revisions NST05A	43.56	7.32	.73[d]	-[f]
19. Memory For Hidden Transformations MST01B	19.23	4.39	.65	-
20. Memory For Misspelling MST02B	27.91	2.35	.69	--[e]
21. Memory For Word Transformations MST03A	20.42	6.42	.67	-
22. Multiple Grouping DMC02D	8.71	2.44	.65[c]	0
23. Multiple Letter Changes DST02A	13.32	6.13	.70[d]	+[f]
24. Multiple Symbolic Implications DSI03A	40.83	7.55	.72[d]	-[f]
25. Multiple Word Extractions DST03A	40.94	9.26	.78[c]	-[f]
26. New Uses NMT05A	15.64	3.30	.47[d]	0
27. Number-Letter Association MSI08A	15.75	5.39	.83	0
28. Numerical Operations MSI01B	32.54	11.41	.89[d]	+[f]
29. Object Synthesis NMT02A	6.47	2.80	.41[d]	0
30. Pertinent Questions CMI02C	12.87	1.87	.38[c]	-
31. Plot Titles DMT01G	5.12	2.59	.49[c]	0
32. Punch-Line Comparisons EMT07A	13.59	5.06	.31	0
33. Reading Backwards CST02A	29.14	2.50	.90	--[e]
34. Reading Confused Words CST03A	15.52	2.36	.68	-
35. Remembering Puns MMT03A	26.66	3.29	.78	-
36. Seeing Different Meanings CMT05A	50.03	5.13	.75[c]	0
37. Seeing Letter Changes CST04A	26.88	4.29	.77	-
38. Seeing Problems CMI04B	23.35	3.14	.66[c]	-
39. Seeing Puzzle Meanings CMT04A	15.52	2.70	.61[d]	-
40. Symbol Elaboration DSI01B	25.69	8.85	.86[d]	-
41. Useful Changes EMT03B	9.11	3.78	.51	0
42. Verbal Comprehension CMU02D	15.55	3.86	.73	0
43. Verbal-Picture Translation CMT06A	17.09	4.36	.63[d]	0
44. Whoppers DMT05A	19.56	5.52	.65[c]	0
45. Word Completion CMU01B	13.68	2.60	.65	0
46. Word-Pair Revisions DSI04A	19.43	5.24	.73[d]	0
47. Sex	.51	.50		
48. Studying And Remembering	18.78	3.77	.29[d]	0

[a] Reported reliability estimates are Kuder-Richardson coefficients unless noted.

[b] Distribution forms are coded: --, strong negative skew; -, slight negative skew; 0, symmetrical; and +, slight positive skew.

[c] Items not dichotomously scored and no speededness; reliability estimate is item-alpha coefficient.

[d] Tests showed evidence of speededness; reliability is part-alpha coefficient.

[e] Raw test scores dichotomized for correlational analysis.

[f] Raw test scores C-scaled for correlational analysis.

Table 3

Correlation Matrix of 48 Variables (N=197)

Test Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Alternate Uses		33	09	09	35	-05	33	02	00	25	24	21	32	19	23	00	-15	07	09	-10
2. Apparatus Test	33		05	11	30	-09	33	09	05	18	07	08	36	16	25	-01	-05	06	00	-09
3. Camouflaged Words	09	05		12	-14	21	18	04	30	14	24	14	27	22	06	07	25	32	01	04
4. Cartoons	09	11	12		09	00	18	09	00	21	21	10	12	17	13	06	17	14	05	-04
5. Consequences	35	30	-14	09		03	20	02	00	22	08	27	35	11	16	08	-08	18	-01	06
6. Correct Spelling	-05	-09	21	00	03		13	04	40	13	19	13	25	22	03	-02	22	28	13	41
7. Daffynitions	33	33	18	18	20	13		05	18	24	19	20	45	30	09	01	19	24	15	07
8. Decoding	02	09	04	09	02	04	05		14	09	06	14	06	13	21	-01	22	20	12	-06
9. Disemvowelled Words	00	05	30	00	00	40	18	14		19	32	18	35	18	12	08	38	51	19	36
10. Double Meanings	25	18	14	21	22	13	24	09	19		28	15	41	35	11	06	08	20	12	22
11. Efficient Word Transformations	24	07	24	21	08	19	19	06	32	28		32	35	42	18	05	26	35	31	27
12. Finding Letter Transformations	21	08	14	10	27	13	20	14	18	15	32		40	32	16	04	17	32	18	-03
13. Hidden Word Production	32	36	27	12	35	25	45	06	35	41	35	40		36	14	05	16	49	11	07
14. Homonyms	19	16	22	17	11	22	30	13	18	35	42	32	36		18	04	29	27	30	36
15. Judging Mathematical Expressions	23	25	06	13	16	03	09	21	12	11	18	16	14	18		05	24	11	23	-06
16. Judging Object Adaptations	00	-01	07	06	08	-02	01	-01	08	06	05	04	05	04	05		02	03	-03	-02
17. Jumbled Words	-15	-05	25	17	-08	22	19	22	38	08	26	17	16	29	24	02		38	20	22
18. Limited Word Revisions	07	06	32	14	18	28	24	20	51	20	35	32	49	27	11	03	38		22	27
19. Memory for Hidden Transformations	09	00	01	05	-01	13	15	12	19	12	31	18	11	30	23	-03	20	22		32
20. Memory for Misspelling	-10	-09	04	-04	06	41	07	-06	36	22	27	-03	07	36	-06	-02	22	27	32	
21. Memory for Word Transformations	04	-06	11	-10	-05	23	10	09	22	17	13	11	14	23	05	03	20	14	33	48
22. Multiple Grouping	34	37	16	06	22	-06	32	01	-01	11	14	06	27	13	14	01	05	02	-04	-06
23. Multiple Letter Changes	15	12	31	23	08	18	27	10	28	27	45	30	44	36	19	04	21	41	15	15
24. Multiple Symbolic Implications	20	30	22	25	25	05	21	29	23	22	28	20	31	25	40	15	26	28	12	-11
25. Multiple Word Extractions	23	18	22	18	17	21	36	16	29	32	30	23	48	39	15	02	18	40	10	30
26. New Uses	38	18	11	23	27	-13	15	14	01	20	14	25	23	10	05	01	-01	12	-02	-03
27. Number-Letter Association	12	-02	28	05	02	21	05	07	38	14	24	19	16	31	12	12	21	31	18	32
28. Numerical Operations	12	10	23	09	17	18	23	10	31	12	26	34	31	23	36	13	31	33	04	15
29. Object Synthesis	28	12	02	12	09	-08	12	-04	-02	13	12	09	09	10	07	14	02	05	-01	-07
30. Pertinent Questions	39	38	-03	09	37	-15	15	-04	-07	17	06	09	20	00	06	-07	-25	-07	-20	-20
31. Plot Titles	33	19	08	11	30	17	23	04	13	16	11	20	32	16	20	-02	05	07	01	-08
32. Funch-Line Comparisons	18	11	08	15	12	02	29	-02	10	15	19	15	17	05	05	19	14	12	09	08
33. Reading Backwards	01	-04	18	13	18	18	04	05	44	01	24	28	17	18	08	07	14	36	18	26
34. Reading Confused Words	15	10	23	12	07	20	18	10	32	24	39	26	39	36	14	11	30	34	23	21
35. Remembering Puns	26	14	21	21	20	29	28	16	23	43	35	21	42	45	16	00	12	37	16	17
36. Seeing Different Meanings	44	28	14	24	37	20	42	07	19	28	10	23	52	20	09	-03	05	23	-02	-02
37. Seeing Letter Changes	16	11	17	17	19	13	24	14	30	39	41	38	44	47	17	03	20	37	20	27
38. Seeing Problems	32	31	-04	06	27	-06	33	04	-06	17	03	21	24	-01	10	00	00	06	-10	-12
39. Seeing Puzzle Meanings	12	03	30	15	12	27	22	11	36	24	35	21	35	42	14	03	15	40	23	30
40. Symbol Elaboration	19	21	16	08	10	28	26	05	19	14	22	20	27	22	33	-12	26	16	23	10
41. Useful Changes	33	11	06	13	22	-05	10	-08	04	14	13	07	14	10	06	10	-06	13	15	-02
42. Verbal Comprehension	28	13	07	20	38	23	13	12	05	30	21	24	33	23	25	06	02	22	04	-01
43. Verbal-Picture Translation	24	16	40	23	08	12	25	15	28	34	31	28	32	46	11	06	10	31	17	18
44. Whoppers	39	38	09	13	34	02	30	-06	01	19	14	19	36	05	06	04	-15	10	-05	-06
45. Word Completion	27	19	02	13	31	24	11	07	05	32	13	19	36	18	13	04	-14	18	-09	05
46. Word-Pair Revisions	20	15	35	07	15	25	31	19	47	27	45	30	43	35	18	23	36	54	16	29
47. Sex	05	10	06	28	12	-18	08	09	-03	-13	-02	01	05	-19	30	00	-03	06	-17	-43
48. Studying and Remembering	01	12	03	13	25	18	17	19	-03	34	15	17	25	30	19	00	07	09	-03	08

Note. — Decimal points omitted.

Tests were revised after the analysis of each pretest if it was necessary to improve item difficulty levels and reliability estimates.

Subjects

The subjects were 197 tenth-, eleventh-, and twelfth-grade students at a middle-class urban senior high school in Los Angeles.[3] The subjects were selected from the school's "gifted" program, and were therefore expected to represent a highly talented group of young people. The sample was composed of 100 males and 97 females, of whom 77 were sophomores, 78 were juniors, and 42 were seniors.

Test Administration

Administration of aptitude and learning tests took place in a large cafeteria in four two-hour sessions on four consecutive days. The first and fourth sessions were held in the early morning of school hours, the second during the late morning, and the third during the early afternoon. All examinees were tested at the same time with the minor exception of two small groups of Es who each took one two-hour make-up session on the fifth day, because of absence during the first or second day of testing.

The tests were printed in eight booklets with the restriction that no factor was represented by more than one test in the same booklet. As far as was possible, the administration of tests for the same factor on the same day was avoided. Various types of tests, semantic vs. symbolic, cognition vs. memory vs. production vs. evaluation, were alternated to give Es variety in an otherwise unexciting task. This alternation appeared to work, as E's morale level and cooperation was very high throughout the testing sessions. All test administration was by experienced testers and was proctored by members of the Aptitudes Research Project staff. The only deviation occuring in the administration procedure was the mistiming of the second study page of Double Meanings for all E's. Instead of 1 minute, 3 minutes was allowed.

[3] For this testing we are very much indebted to Mr. John W. Sanders, Principal, Mrs. Shirley Hall, Head Counselor, and Mr. Paul Linker, Senior Counselor, of Alexander Hamilton Senior High School, and to Mrs. Toni Walker, Guidance Specialist with Project APEX, Los Angeles.

Table 3 (Continued)

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
04	34	15	20	23	38	12	12	28	39	33	18	01	15	26	44	16	32	12	19	33	28	24	39	27	20	05	01
-06	37	12	30	18	18	-02	10	12	38	19	11	-04	10	14	28	11	31	03	21	11	13	16	38	19	15	10	12
11	16	31	22	22	11	28	23	02	-03	08	08	18	23	21	14	17	-04	30	16	06	07	40	09	02	35	06	03
-10	06	23	25	18	23	05	09	12	09	11	15	13	12	21	24	17	06	15	08	13	20	23	13	13	07	28	13
-05	22	08	25	17	27	02	17	09	37	30	12	18	07	20	37	19	27	12	10	22	38	08	34	31	15	12	25
23	-06	18	05	21	-13	21	18	-08	-15	17	02	18	20	29	20	13	-06	27	28	-05	23	12	02	24	25	-18	18
10	32	27	21	36	15	05	23	12	15	23	29	04	18	28	42	24	33	22	26	10	13	25	30	11	31	08	17
09	01	10	29	16	14	07	10	-04	-04	04	-02	05	10	16	07	14	04	11	05	-08	12	15	-06	07	19	09	19
22	-01	28	23	29	01	38	31	-02	-07	13	10	44	32	23	19	30	-06	36	19	04	05	28	01	05	47	-03	-03
17	11	27	22	32	20	14	12	13	17	16	15	01	24	43	28	39	17	24	14	14	30	34	19	32	27	-13	34
13	14	45	28	30	14	24	26	12	06	11	19	25	39	35	10	41	03	35	22	13	21	31	14	13	45	-02	15
11	06	30	20	23	25	19	34	09	09	20	15	28	26	21	23	38	21	21	20	07	24	28	19	19	30	01	17
14	27	44	31	48	23	16	31	09	20	32	17	17	39	42	52	44	24	35	27	14	33	32	36	36	43	05	25
23	13	36	25	39	10	31	23	10	00	16	05	18	36	45	20	47	-01	42	22	10	23	46	05	18	35	-19	30
05	14	19	40	15	05	12	36	07	06	20	05	08	14	16	09	17	10	14	33	06	25	11	06	13	18	30	19
03	01	04	15	02	01	12	13	14	-07	-02	19	07	11	00	-03	03	00	03	-12	10	06	06	04	04	23	00	00
20	05	21	26	18	-01	21	31	02	-25	05	14	14	30	12	05	20	00	15	26	-06	02	10	-15	-14	36	-03	07
14	02	41	28	40	12	31	33	05	-07	07	12	36	34	37	23	37	06	40	16	13	22	31	10	18	54	06	09
33	-04	15	12	10	-02	18	04	-01	-20	01	09	18	23	16	-02	20	-10	23	23	15	04	17	-05	-09	16	-17	-03
48	-06	15	-11	30	-03	32	15	-07	-20	-08	08	26	21	17	-02	27	-12	30	10	-02	-01	18	-06	05	29	-43	08
	-02	14	05	25	05	20	15	-06	-12	00	07	12	20	10	03	22	-02	13	21	-07	-04	18	09	-05	28	-22	06
-02		08	14	19	06	-02	16	-01	25	13	14	-19	-06	03	25	09	27	02	19	04	11	03	35	10	18	05	12
14	08		29	38	14	17	23	12	02	12	03	18	22	25	19	43	11	35	15	12	19	36	13	15	37	10	18
05	14	29		30	17	11	41	01	20	21	12	21	18	17	22	31	15	19	17	05	21	20	22	15	32	43	14
25	19	38	30		12	19	43	06	02	23	19	20	15	32	40	33	17	31	31	00	22	28	28	24	43	-02	24
05	06	14	17	12		11	-07	30	13	14	22	10	24	22	23	17	17	16	05	35	17	22	14	15	15	-01	18
20	-02	17	11	19	11		23	10	-11	01	10	18	27	25	07	24	-15	35	13	08	-01	34	03	01	17	-16	-02
15	16	23	41	43	-07	23		-10	07	22	08	25	07	18	18	28	11	18	32	04	11	19	25	07	37	11	10
-06	-01	12	01	06	30	10	-10		04	22	11	03	13	18	14	12	11	12	04	23	14	15	06	13	12	-10	20
-12	25	02	20	02	13	-11	07	04		28	04	-04	-08	05	36	-07	30	-05	08	19	21	07	40	23	07	19	14
00	13	12	21	23	14	01	22	22	28		06	10	07	28	36	12	22	15	18	13	32	16	34	28	05	07	22
07	14	03	12	19	22	10	08	11	04	06		10	14	19	11	02	17	09	15	18	14	14	18	11	17	00	02
12	-19	18	21	20	10	18	25	03	-04	10	10		19	22	18	26	-04	48	-06	08	09	21	02	-02	42	06	-14
20	-06	22	18	15	24	27	07	13	-08	07	14	19		33	24	39	10	39	10	15	18	38	02	14	26	-07	19
10	03	25	17	32	22	25	18	18	05	28	19	22	33		31	30	06	46	21	21	41	44	13	42	28	-16	42
03	25	19	22	40	23	07	18	14	36	36	11	18	24	31		18	41	19	15	14	35	20	45	41	17	11	30
22	09	43	31	33	17	24	28	12	-07	12	02	26	39	30	18		10	39	13	14	11	40	05	13	34	-11	21
-02	27	11	15	17	17	-15	11	11	30	22	17	-04	10	06	41	10		-02	11	17	17	04	37	25	15	10	21
13	02	35	19	31	16	35	18	12	-05	15	09	48	39	46	19	39	-02		18	16	22	46	-01	18	40	-06	17
21	19	15	17	31	05	13	32	04	08	18	15	-06	10	21	15	13	11	18		-03	12	17	15	10	20	07	23
-07	04	12	05	00	35	08	04	23	19	13	18	08	15	21	14	14	17	16	-03		16	18	13	08	15	-03	15
-04	11	19	21	22	17	-01	11	14	21	32	14	09	18	41	35	11	17	22	12	16		22	19	64	19	06	39
18	03	36	20	28	22	34	19	15	07	16	14	21	38	44	20	40	04	46	17	18	22		09	24	34	-04	24
09	35	13	22	28	14	03	25	06	40	34	18	02	02	13	45	05	37	-01	15	13	19	09		20	15	14	11
-05	10	15	15	24	15	01	07	13	23	28	11	-02	14	42	41	13	25	18	10	08	64	24	20		11	04	41
28	18	37	32	43	15	17	37	12	07	05	17	42	26	28	17	34	15	40	20	15	19	34	15	11		-01	08
-22	05	10	43	-02	-01	-16	11	-10	19	07	00	06	-07	-16	11	-11	10	-06	07	-03	06	-04	14	04	-01		06
06	12	18	14	24	18	-02	10	20	14	22	02	-14	19	42	30	21	21	17	23	15	39	24	11	41	08	06	

Test Scoring

All answer-sheet tests were scored by computer as part of a general item-analysis program. Completion tests were scored and then independently check scored. Those tests for which subjective judgment entered into the scoring were scored independently by two scorers and then final scores were arbitrated. Descriptions of the nature of the scores and the scoring formula for each test appear in the Appendix as part of the general description of the test.

Statistical Analysis and Preliminary Results

Descriptive Statistics

Means and standard deviations were computed for total scores of each test and the form of the total-score frequency distribution was inspected for symmetry.[4] Distributions for variables that markedly departed from symmetry were dichotomized near the median or were C-scaled. Kuder-Richardson estimates of test reliability were computed for all tests except those that appeared to be speeded or those having items non-dichotomously scored. Inter-part alpha coefficients were computed for the former exceptions and item alpha coefficients for the latter. The descriptive statistics are reported in Table 2.

[4] For the statistical analyses, computer assistance was obtained from the Campus Computer Network, UCLA, and from the Computer Sciences Laboratory, USC.

The matrix of intercorrelations among the 47 tests and the variable of Sex was computed utilizing the basic Pearson-r formula. This procedure yields point-biserial coefficients between dichotomized and continuous variables, and phi coefficients between dichotomized variables. All point-biserial and phi coefficients were corrected to estimate their corresponding Pearson r's. Correlations involving the Sex variable were treated as true point-biserials, and not corrected for continuity. The resulting correlation matrix is presented in Table 3.

Factor Analysis of the Aptitude Tests

The corrected correlation matrix for 47 variables, excluding the school-learning variate which was to be analyzed later, was factor analyzed by the principal-factors method. The communality estimate utilized in the initial extraction for each variable was

Table 4

Unrotated Factor Matrix

Test Name	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	h^2
1. Alternate Uses	45	48	17	00	25	00	12	07	19	-04	06	-08	-05	-10	-06	08	00	60
2. Apparatus Test	33	44	-08	13	20	-06	-01	-06	-03	01	-09	-23	-05	10	13	-08	01	47
3. Camouflaged Words	39	-18	-16	-07	07	12	-39	13	-23	03	10	-05	00	-06	-11	-04	-05	50
4. Cartoons	30	13	-09	-29	01	-10	-14	03	04	01	-30	28	10	01	00	-01	05	42
5. Consequences	38	43	09	02	-13	13	36	-10	07	01	-03	-01	01	11	08	-10	15	56
6. Correct Spelling	35	-32	09	27	-39	-03	-05	18	-05	-10	02	01	-06	06	-06	07	-03	52
7. Daffynitions	51	19	-06	22	21	03	-18	08	11	-12	-13	10	-04	-01	12	-07	-10	51
8. Decoding	21	-06	-20	-14	-06	-21	04	-03	19	-04	-02	-28	18	-23	04	-08	01	36
9. Disemvowelled Words	50	-40	-15	07	-13	24	-01	12	-07	-10	-02	-20	-02	12	03	07	06	61
10. Double Meanings	50	07	24	03	03	-13	-09	-09	09	17	-10	-04	08	06	-02	06	03	42
11. Efficient Word Transformations	57	-18	-01	-09	12	-05	02	-06	-03	10	00	14	-26	07	-12	01	01	51
12. Finding Letter Transformations	50	03	-06	-10	01	04	18	-15	14	-18	40	18	01	-09	-14	-17	-02	62
13. Hidden Word Production	72	16	02	13	-06	10	-17	-11	12	-11	10	-05	-08	14	-04	01	05	68
14. Homonyms	60	-21	16	01	12	-27	-04	-20	-05	08	01	07	01	00	14	-12	-14	62
15. Judging Mathematical Expressions	34	10	-37	-10	00	-40	29	11	-12	04	03	-08	-05	05	06	11	-01	57
16. Judging Object Adaptations	10	-03	-04	-16	06	17	07	20	08	38	12	03	13	18	00	02	-17	36
17. Jumbled Words	35	-39	-33	03	06	-14	-04	25	25	-11	03	03	02	05	16	01	01	58
18. Limited Word Revisions	61	-27	-13	-07	-14	20	-06	02	15	-07	02	-08	-09	-02	-02	-02	24	63
19. Memory for Hidden Transformations	28	-33	05	04	20	-25	31	02	00	-15	-14	03	-18	00	-12	-04	-06	49
20. Memory for Misspelling	30	-56	31	36	-01	06	20	-04	00	13	-25	02	04	07	01	04	10	77
21. Memory for Word Transformations	27	-35	08	33	16	-05	18	-01	04	01	-06	-09	20	-12	-28	11	-13	54
22. Multiple Grouping	25	35	-13	30	23	-03	-13	03	-02	12	03	-05	-13	02	09	-14	04	43
23. Multiple Letter Changes	55	-11	-10	-11	04	-02	-19	-22	03	05	01	11	-14	-02	-11	23	06	53
24. Multiple Symbolic Implications	49	15	-48	-18	-01	-10	10	-07	00	12	-11	-10	14	08	-02	03	-04	62
25. Multiple Word Extractions	61	-03	-07	26	-04	02	-10	-07	05	10	-08	14	17	-19	05	09	08	58
26. New Uses	33	24	22	-32	26	09	07	09	11	-11	-02	-07	16	-16	-08	02	19	52
27. Number-Letter Association	37	-34	08	-05	10	03	02	11	-29	00	12	-05	23	14	-01	-07	18	49
28. Numerical Operations	48	-06	-43	20	-08	04	14	-02	-15	14	21	17	14	00	10	-02	05	64
29. Object Synthesis	20	15	24	-26	19	01	01	19	01	00	11	06	00	-05	17	29	-02	40
30. Pertinent Questions	18	59	01	07	00	11	06	-12	-18	04	-06	-12	-08	00	-03	-05	00	48
31. Plot Titles	38	32	04	06	-16	-06	08	07	-17	-16	09	09	05	-03	12	16	-10	41
32. Punch-Line Comparisons	28	09	05	00	17	10	05	38	13	09	-10	19	04	03	-08	-19	02	39
33. Reading Backwards	39	-28	-09	-23	-20	43	29	-08	-11	-11	-15	08	-02	-11	11	-06	-16	71
34. Reading Confused Words	50	-21	15	-20	10	-04	-04	06	12	-18	03	-14	03	28	-11	-03	-16	56
35. Remembering Puns	60	-03	30	-11	-16	-17	-08	09	-08	00	-04	01	00	-08	11	-10	02	57
36. Seeing Different Meanings	53	41	09	15	-17	14	-11	02	04	-26	-10	00	15	04	03	05	-11	66
37. Seeing Letter Changes	58	-19	05	-10	13	-05	01	-38	11	-01	09	04	06	13	08	09	02	61
38. Seeing Problems	27	46	-01	14	09	09	02	02	23	-07	03	00	01	00	01	05	-11	39
39. Seeing Puzzle Meanings	57	-27	13	-19	-08	05	-03	-05	-19	-06	-11	-02	-08	-06	12	-07	-06	55
40. Symbol Elaboration	38	01	-18	29	06	-30	02	18	-12	-14	03	06	-08	-08	-06	00	11	45
41. Useful Changes	25	18	22	-25	20	13	13	12	-07	01	-02	02	-12	04	00	07	10	32
42. Verbal Comprehension	45	29	20	-13	-44	-21	08	14	09	15	04	02	-11	-05	-07	-04	-03	67
43. Verbal-Picture Translation	57	-12	16	-21	10	-06	-19	-07	-21	05	00	-06	10	-08	-06	-11	-08	55
44. Whoppers	36	49	-04	28	07	19	02	-01	-12	02	-02	09	08	05	-16	01	-04	55
45. Word Completion	41	34	30	-02	-47	-16	-06	05	07	17	05	-06	02	01	-09	-01	02	67
46. Word-Pair Revisions	65	-21	-17	04	07	29	03	07	15	28	03	-18	-21	-23	03	04	-09	82
47. Sex	02	35	-60	-28	-15	01	-05	-03	-06	-05	-22	04	-02	05	-19	03	01	68

Note. — Decimal points omitted.

the squared multiple R for that variable when the remaining 46 variables served as predictors. Extractions were iterated until communality estimates stabilized to within .04 between successive extractions. Thirty-one factors with positive eigenvalues were extracted, of which 17, the hypothesized number, were retained for rotation. The first 17 factors, accounting for 91.8% of the total common-factor variance, and all having eigenvalues greater than .38, are presented in Table 4.

The computer program that extracts the principal factors also provides varimax rotations of them. Although it was not expected that the 17-factor varimax solution would yield psychologically interpretable results (Guilford & Hoepfner, 1969) its complete determination by the correlational pattern would indicate some dimensions that would underlie whatever factor pattern was finally accepted. Of the 17 varimax factors, only 9 were in any way interpretable, and only one of the nine was a hypothesized SI factor. The largest varimax factor could have been interpreted as a general "transformation" factor, having significant loadings from 13 tests of symbolic and semantic transformations. The second factor could be called "verbal flexibility," for it was defined by loadings on all the open-ended verbal tests, primarily those of CMI, DMC, and DMT. A sex factor emerged, led by variable 47. The fourth varimax factor appeared to involve "object flexibility," since it was defined by the tests in which object redefinitions are involved. A kind of verbal-comprehension factor emerged, but it was supported by a variety of semantic tests; and a "general-mathematics" factor was defined by all the tests involving the manipulation of numbers. The MST factor emerged just as hypothesized, the only one to do so. A strong "word" factor was defined by all tests involving words as symbols, primarily where letter replacements and rearrangements were involved. The last interpretable varimax factor appeared to be a weak "humor" factor, defined by the three tests involving jokes. All the remaining varimax

factors were singlets or residuals and were therefore uninterpretable.

The 17 principal factors were rotated orthogonally to a least-squares fit to the hypothesized factor target matrix (Cliff, 1966). The initial target for each test was composed of values of zero on unexpected factors and the square-root of the communality on its expected factor. Each subsequent least-squares solution was then adjusted to "yield" to the realities forced upon the solution by the correlations. Human limitations in foreseeing the results of whole-matrix orthogonal rotations precludes the possibility that the method is wholly satisfactory, so slight graphic adjustments were made after continuation of the computer rotations did not appear to improve the factor picture. This rotational procedure resulted in the final factor matrix in Table 5, which exhibited psychological meaningfulness and simple structure, but lacked positive manifold, due to the large number of negative correlations between tests.

Analysis of Learning Scores

In order to have generality, the determination of the relationship between learning scores and ability variables involved the use of aptitude factors rather than individual tests. The correlation matrix of Table 3 indicates that 26 of the 46 tests correlated with the learning variable beyond the .05 level of significance. Correlations between aptitude tests and the learning score tell us little that is generalizable, unless we can relate the test variable to some more stable and enduring variable, hopefully one that is embedded in sound theory. Factors supply us with those variables and the obtained factor-score correlations with the learning score are generalizable, indicating the importance of each factor ability to the performance of the learning task.

A second method of determining the aptitude-learning relationships is through extension of the learning measure into the rotated factor structure for aptitudes, as Dunham, et al., (1966) did. Both methods--correlation of factor scores with learning scores and extension of learning scores onto the factor structure--should yield roughly parallel results, with similar interpretations. The former method permits statistical evaluation of the relationships and the latter does not. In a multiple prediction of the learning scores from the factor scores, the regression weights can be tested for significance

Table 5

Rotated Factor Matrix

Test Name	CSU	CST	CMU	CMT	CMI	MST	MSI	MMT	DST	DSI	DMI	DMT	NST	NMT	EST	EMT	SEX	h^2
1. Alternate Uses	-05	07	16	22	27	04	10	10	07	09	47	26	02	36	-06	-01	03	60
2. Apparatus Test	-03	-04	00	18	52	-07	05	16	08	16	22	20	01	04	08	00	04	47
3. Camouflaged Words	20	06	-03	29	-08	-06	25	-01	15	17	18	-27	35	-01	-05	07	05	50
4. Cartoons	-19	01	03	39	-08	-06	00	15	12	04	-14	08	10	15	10	15	29	42
5. Consequences	-07	20	24	05	32	00	08	09	04	09	-04	56	00	13	-03	03	-02	56
6. Correct Spelling	51	04	24	11	-18	24	07	09	15	-04	-05	06	14	-16	05	01	-08	52
7. Daffynitions	05	03	-08	43	21	06	-03	10	29	07	23	19	12	-02	14	19	-07	51
8. Decoding	09	11	17	14	10	05	08	-04	03	23	-11	-16	-01	02	40	-16	-04	36
9. Disemvowelled Words	52	23	-07	13	01	20	20	-02	12	23	-14	00	29	02	08	02	-03	61
10. Double Meanings	00	07	22	22	16	17	06	36	29	13	-01	01	03	15	-05	08	-04	41
11. Efficient Word Transformations	04	28	02	08	-07	24	01	28	21	17	14	04	37	07	02	13	13	51
12. Finding Letter Transformations	-14	58	19	05	-03	05	17	-07	24	-02	18	16	19	01	16	06	-08	62
13. Hidden Word Production	21	29	18	26	29	01	07	15	47	08	10	18	26	03	01	07	-04	68
14. Homonyms	-03	29	02	27	-04	24	13	52	18	12	12	-05	11	-06	11	01	-11	62
15. Judging Mathematical Expressions	06	08	10	-05	06	05	19	20	-03	23	19	14	01	07	48	-02	35	57
16. Judging Object Adaptations	03	12	03	-10	-05	-10	12	05	-06	27	-03	-07	-07	10	-08	45	00	36
17. Jumbled Words	23	11	-15	10	-11	12	06	04	18	10	-10	-10	20	-05	54	22	-05	58
18. Limited Word Revisions	25	27	08	17	01	11	10	-01	28	22	-20	07	48	09	14	01	-08	63
19. Memory For Hidden Transformations	03	20	-07	02	-05	54	-08	17	-08	-01	12	01	14	03	24	00	08	49
20. Memory For Misspelling	24	00	-09	02	-12	67	09	26	10	09	-24	08	07	-04	-13	05	-24	77
21. Memory For Word Transformations	11	09	01	05	-03	63	16	-07	18	12	09	-15	-12	-03	03	04	-08	55
22. Multiple Grouping	-08	-17	-03	09	35	-08	08	10	17	11	33	18	13	-11	05	13	-07	43
23. Multiple Letter Changes	04	24	01	13	-07	07	01	20	48	21	06	-04	28	10	00	-04	18	53
24. Multiple Symbolic Implications	-03	20	08	17	20	-03	23	07	15	41	-03	08	05	00	29	08	38	62
25. Multiple Word Extractions	04	01	08	32	-05	19	23	11	48	26	02	19	08	-02	08	03	-10	58
26. New Uses	-21	16	13	25	16	04	04	-06	05	02	04	04	09	57	02	03	-08	53
27. Number-Letter Association	20	17	-07	10	-04	20	49	16	-03	-02	-04	-11	22	18	-01	06	-06	49
28. Numerical Operations	09	16	-03	01	-09	03	50	04	26	28	09	28	12	-19	21	11	06	64
29. Object Synthesis	05	08	00	09	-09	-14	-06	16	06	04	18	04	-08	51	02	09	-07	40
30. Pertinent Questions	-09	-04	17	12	37	-15	04	00	01	13	25	34	-02	04	-20	-09	13	48
31. Plot Titles	19	12	19	22	00	-11	13	10	12	-01	25	35	-13	11	08	-05	07	41
32. Punch-Line Comparisons	-07	-03	07	22	02	13	04	-04	-03	03	07	14	17	14	06	47	-06	39
33. Reading Backwards	18	48	-10	26	-24	14	04	-11	-15	35	-19	27	16	01	-07	-07	00	71
34. Reading Confused Words	24	45	07	22	16	18	-01	19	06	-04	-01	-21	13	17	10	19	03	56
35. Remembering Puns	12	15	32	40	-07	09	09	40	06	05	04	08	20	16	06	-02	-13	57
36. Seeing Different Meanings	21	13	22	51	26	-07	04	-02	29	00	10	33	-10	06	-03	03	00	66
37. Seeing Letter Changes	-02	48	-08	09	07	16	12	35	39	13	-07	-01	09	10	06	-03	-03	61
38. Seeing Problems	-04	07	12	17	30	-09	-11	-09	25	07	21	26	-13	07	05	15	-04	39
39. Seeing Puzzle Meanings	20	32	02	36	-14	15	08	29	-01	19	-02	03	28	09	-02	-10	-04	55
40. Symbol Elaboration	12	-11	07	12	02	23	18	08	18	-06	29	15	19	-05	34	-01	09	45
41. Useful Changes	-03	13	01	07	07	01	-05	11	-07	04	13	17	14	43	-11	11	03	32
42. Verbal Comprehension	06	10	68	14	-03	-06	-06	25	06	11	05	24	08	08	08	07	05	67
43. Verbal-Picture Translation	00	26	12	40	-02	11	23	29	08	15	13	-19	22	14	-07	-03	00	55
44. Whoppers	-02	-01	12	21	29	02	19	-09	24	07	28	36	-04	-01	-20	15	11	55
45. Word Completion	11	03	69	16	09	-09	01	26	16	04	-01	17	-01	06	-08	03	-02	67
46. Word-Pair Revisions	18	22	03	11	00	18	01	00	23	67	12	03	33	05	07	14	-19	82
47. Sex	-11	-02	05	13	11	-30	01	-26	02	18	-07	10	09	-08	15	-02	63	68

Note. — Decimal points omitted.

Table 6

Predicting School-Learning Scores from Factor Scores and Sex: Intercorrelations, Order of Entry into the Regression Equation, and Significant Beta Weights

	CSU	CST	CMU	CMT	CMI	MST	MSI	MMT	DST	DSI	DMC	DMT	NST	NMT	EST	EMT	SEX	Sch. Lrn.	Entry Ord.	Beta Wt.
CSU		01	-04	-08	03	-10	-05	04	01	-01	09	-04	-11	08	-01	-01	-13	-02	16	
CST	01		01	-04	04	-04	-04	-02	-05	-08	09	-07	-11	-12	-04	04	-08	04	9	
CMU	-04	01		-03	02	11	05	-12	-03	02	-01	-11	05	-04	00	01	07	34	1	.395**
CMT	-08	-04	-03		-03	00	-04	-05	-10	-02	00	-06	-08	-11	02	00	12	16	3	.223**
CMI	03	04	02	-03		06	04	02	-11	01	-13	-09	09	-05	01	-01	08	01	10	
MST	-10	-04	11	00	06		-05	-14	-01	-03	03	-03	01	01	-04	-02	-20	01	14	
MSI	-05	-04	05	-04	04	-05		-03	-04	-03	-06	-05	00	04	-03	-02	-02	-02	17	
MMT	04	-02	-12	-05	02	-14	-03		-04	04	-03	05	-01	-04	-01	02	-25	24	2	.320**
DST	01	-05	-03	-10	-11	-01	-04	-04		-02	-03	-01	-04	13	-04	-06	05	16	4	.195**
DSI	-01	-08	02	-02	01	-03	-03	04	-02		01	-06	-11	01	-02	-05	17	-01	15	
DMC	09	09	-01	00	-13	03	-06	-03	-03	01		-04	-01	-07	-02	-03	-14	12	6	.155**
DMT	-04	-07	-11	-06	-09	-03	-05	05	-01	-06	-04		04	03	04	01	08	05	8	
NST	-11	-11	05	-08	09	01	00	-01	-04	-11	-01	04		-03	-03	-04	11	-07	12	
NMT	08	-12	-04	-11	-05	01	04	-04	13	01	-07	03	-03		05	-06	-03	11	7	.144*
EST	-01	-04	00	02	01	-04	-03	-01	-04	-02	-02	04	-03	05		-06	10	16	5	.165**
EMT	-01	04	01	00	-01	-02	-02	02	-06	-05	-03	01	-04	-06	-06		02	-05	13	
SEX	-13	-08	07	12	08	-20	-02	-25	05	17	-14	08	11	-03	10	02		03	11	
Sch.Lrn.	-02	04	34	16	01	01	-02	24	16	-01	12	05	-07	11	16	-05	03			

Note: decimal points omitted for correlation coefficients.

through F tests, to indicate which abilities make significant contributions to prediction beyond that possible by chance. Since the sampling distribution of extended factor loadings, or even extracted ones for that matter, is unknown, no probability statements can be attached to the relationships found by that procedure.

Following the advice of Harris (1967), it was decided to compute estimates of factor scores using Bartlett's (1937) method. The computation of factor scores, in general, is an attempt to estimate the common portions of the data that are unobservable by multiplying the factor coefficients by the observed factor measurements in some way. Bartlett's method of multiplying assumes that unique factors are the underlying cause of the discrepancies between observed factor measurements (test scores) and the uncomputable "true" factor scores. For each individual, Bartlett's method minimizes the sum of squares of unique factor scores over all variables analyzed. This results in a set of factor scores that will be relatively uncorrelated with other factor scores in an orthogonal solution, and will be univocal, i.e., uncorrelated with other "true factor scores." The univocality resulting from this method means that the obtained factor scores are correlated only with their corresponding "true" factors. Harris provides a table indicating that for this study, the correlations between the obtained and the "true" factor scores could be expected maximally to range from .58 to .83. The procedure for analyzing the learning scores was to use the aptitude-factor scores as predictors in a stepwise multiple regression and then to evaluate the significance of the predictive validities of the contributions of the factors.

Table 6 presents the intercorrelations among factor scores, sex membership, and the learning measure. As can be seen, the factor-score intercorrelations are small, and do not deviate greatly from zero. The near-zero values of the intercorrelations, however, virtually eliminate linear restraints within the prediction equation of the learning measure as a function of factor scores. The last column of Table 6 presents the significant beta weights for the factor scores in prediction of the learning measure. The beta weights are computed from a stepwise-multiple-regression procedure that maximizes the R^2 for the number of predictors entered into the regression equation. Those beta weights that contribute predictive variance significant at or beyond the .05 level are marked in Table 6 with asterisks. The order of entry into the regression equation, for those factor-score predictors that were significant, was: CMU, MMT, CMT, DST, EST, DMC, MSI; and their predictive validity was $R = .58$. The raw-score regression equation for factors making a significant contribution to the prediction is as follows:

$$\text{Learning Score} = 18.782 + 1.238\text{CMU} + .974\text{MMT} + .668\text{CMT} + .576\text{DST} + .511\text{EST} + .461\text{DMC} + .415\text{NMT}$$

RESULTS

Interpretation of the Factors

The interpretation of each of the rotated factors is based upon the apparent factor content of the tests loading .30 or higher on the factor. It is from the common psychological features of the tests that the nature of the factor is inferred. The test loadings for the factor in question are listed along with any additional significant loadings of the tests, where they proved to be factorially complex. Each test name is preceded by its number in the battery and is followed by the trigram for its hypothesized factor. The factors are discussed in the order of their appearance in Table 5.

CSU - Cognition of Symbolic Units

9. Disemvowelled Words (CSU)	.52	
6. Correct Spelling (CSU)	.51	

The CSU factor, representing the ability to recognize symbolic units was demonstrated with greater clarity then ever before. The development of new NST tests has apparently directed that factor's vector more clearly away from CSU tests, so that their mutual involvement in tests is minimal. The revision of the MST test Memory for Misspelling, which had its highest loading on CSU (Tenopyr, et al., 1967), has apparently resulted in a loading of only .24 in this analysis.

CST - Cognition of Symbolic Transformations

12. Finding Letter Transformations (CST)	.58	
33. Reading Backwards (CST)	.48	(.35 DSI)
37. Seeing Letter Changes (CST)	.48	(.39 DST; .35 MMT)
34. Reading Confused Words (CST)	.45	
39. Seeing Puzzle Meanings (CMT)	.32	(.36 CMT)

The CST factor represents the first empirical demonstration of that ability by the Aptitudes Research Project. It had possibly been reported by Mooney (1954), but his solution was by no means decisive. One type of test is in common to the two analyses--Mooney's Spoonerisms, and Reading Confused Words. The latter is univocal in this study but Spoonerisms was complex in Mooney's analysis.

The hypothesis that CST represents the ability to recognize that specific transformations have occurred appears to be borne out. The four leading tests on the CST factor were all hypothesized for that factor. The expectation that Seeing Puzzle Meanings might have symbolic involvement, due to the need for Es to translate some numbers and letters into words with similar sounds, was also confirmed.

The DSI side loading for Reading Backwards might imply that Es did not actually carefully read backwards but quickly scanned important elements of the backward words and then produced implications about what words were printed until a meaningful phrase was formed. Or, having grasped one or two words correctly, they implied the others in the statement, in variety, until the correct completion was achieved.

The DST loading for Seeing Letter Changes probably arose because some of the letter changes can be redefined, and must be, in order to find a correct alternative. If "dim" becomes "din," E may see that the last letter progressed one place further alphabetically, but if no alternative represents such a change, E must redefine the change so that the last letter simply changes. Such multiple reinterpretation is common to tests for DST. With a reliability estimate of .77 and a communality estimate of .61, the expectation that Seeing Letter Changes may have CSR involvement cannot be rejected with confidence.

CMU - Cognition of Semantic Units

45. Word Completion (CMU)	.69	
42. Verbal Comprehension (CMU)	.68	
35. Remembering Puns (MMT)	.32	(.40 MMT; .40 CMT)

The verbal-comprehension factor emerged as expected, univocally marked by the two tests that have consistently measured it. The revision of Remembering Puns was not wholly successful, merely resulting in the lowering of its CMU component. It should also be pointed out that this analysis showed Remembering Puns to be a rather complex test, as will be discussed later.

CMT - Cognition of Semantic Transformations

36. Seeing Different Meanings (CMT)	.51	(.33 DMT)
7. Daffynitions (NMT)	.43	
43. Verbal Picture Translation (CMT)	.40	
35. Remembering Puns (MMT)	.40	(.40 MMT; .32 CMU)
4. Cartoons (CMT)	.39	
39. Seeing Puzzle Meanings (CMT)	.36	(.32 CST)
25. Multiple Word Extractions (DST)	.32	(.48 DST)

The CMT factor, isolated in relation to an unusual number of tests, is clearly concerned with the ability to see potential changes and interpretations of words and ideas. The attempt to obtain clear separation between CMT and CMI tests was successful in this analysis, although there appears to be some slight other-factor involvement in its tests. Daffynitions, hypothesized as a test of NMT, is univocally loaded on the cognition factor, implying that the task for E is seeing that there is a reinterpretation; once seen, the production of the reinterpretation is apparently trivial.

The suspicion that Remembering Puns could conceivably be responded to without reference to stimuli from the study page, and therefore without memory involvement, was confirmed by its loading of .40 on CMT. E's task is to understand the pun or else to see what real word could replace a pun word. The marginal loading of Multiple Word Extractions on CMT could only be explained if E's performance were based on meanings; a translation of symbolic information into semantic form.

The leading CMT test, Seeing Different Meanings, has some DMT involvement, probably due to the fact that E must define and redefine the words in multiple ways--up to four ways. Some of the meanings may not be very familiar to some Es who have to resort to the more active approach of inventing (producing) meanings, some of which are recognized by the scorer as acceptable. Seeing Puzzle Meanings' CST loading was discussed under that factor.

CMI - Cognition of Semantic Implications

2. Apparatus Test (CMI)	.52	
30. Pertinent Questions (CMI)	.37	(.34 DMT)
22. Multiple Grouping (DMC)	.35	(.33 DMC)
5. Consequences (DMT)	.32	(.56 DMT)
38. Seeing Problems (CMI)	.30	

All three tests designed to measure CMI, the ability to anticipate needs or consequences of situations, are loaded on this factor, but the factor enters into other tests with unusual frequency. Apparatus Test and Seeing Problems once again prove to be univocal measures, but the latter test's loading just barely reaches the .30 mark. Pertinent Questions split its variance, one part going on DMT, which it has not done before. But among the tests hypothesized for CMI, Pertinent Questions asks for the greatest number of varied responses, and on that

basis might be expected to have divergent-production variance.

Multiple Grouping has previously been a univocal measure of DMC, but in this analysis it also exhibits CMI variance. In a similar manner, Consequences shares its variance with CMI, not a novel finding, and somewhat anticipated. Reasons for CMI variance in Consequences was discussed earlier.

MST - Memory for Symbolic Transformations

20. Memory for Misspelling (MST)	.67	
21. Memory for Word Transformations (MST)	.63	
19. Memory for Hidden Transformations (MST)	.54	
47. Sex	-.30	(.63 SEX)

This factor is strongly and univocally defined by its three hypothesized tests as the ability to remember changes in symbolic information. All three tests have higher loadings on the MST dimension than they have had before. The significant negative sex loading indicates more strongly than was indicated by the findings of Tenopyr, et al., (1966), that females are better at this mnemonic ability than males. This result is in line with frequently reported superiority of females in memory tests (Anastasi, 1958).

MSI - Memory for Symbolic Implications

28. Numerical Operations (MSI)	.50	
27. Number-Letter Associations (MSI)	.49	

The two tests hypothesized to define MSI, the ability to remember arbitrary connections between symbols, emerged with unexpected clarity. The loading for Numerical Operations on this factor is a little higher than usual. The strength of Number-Letter Association on it indicates that it is not the same as the traditional numerical-facility factor. No number operations are involved in the latter test.

MMT - Memory for Semantic Transformations

14. Homonyms (MMT)	.52	
35. Remembering Puns (MMT)	.40	(.40 CMT; .32 CMU)
10. Double Meanings (MMT)	.36	
37. Seeing Letter Changes (CST)	.35	(.48 CST; .39 DST)

The ability to remember changes in meanings or redefinitions, MMT, is more clearly represented here than in the Brown, et al., study (1968). This clarity may be artifactual, however, insofar as there were no other semantic-memory factors in this analysis. The three MMT tests led on this factor, with Remembering Puns being the only complex MMT test. The marginal loading of Seeing Letter Changes on MMT has no obvious explanation. The separation of MMT from MST and MSI in this analysis constitutes one of the first systematic attempts to separate memory factors of different contents.

DST - Divergent Production of Symbolic Transformations

23. Multiple Letter Changes (DST)	.48	
25. Multiple Word Extractions (DST)	.48	(.32 CMT)
13. Hidden Word Production (DST)	.47	
37. Seeing Letter Changes (CST)	.39	(.48 CST; .35 MMT)

The second completely new factor found in this analysis, DST, is defined by three tests hypothesized as DST measures. All three tests are concerned with letters and words and the varied production of changes or alterations of them. The small CMT loading for Multiple Word Extractions was discussed under that factor. The CST test, Seeing Letter Changes, was discussed under its factor.

DSI - Divergent Production of Symbolic Implications

46. Word-Pair Revisions (DSI)	.67	(.33 NST)
24. Multiple Symbolic Implications (DSI)	.41	(.38 SEX)
33. Reading Backwards (CST)	.35	(.48 CST)

The ability to produce varied implications of symbolic information, DSI, was not found with the strength expected. The reason is that Symbol Elaboration is missing from the list of DSI tests. It had previously been a strong marker for what was believed to be DSI, but had usually exhibited loadings on other factors as well. It is too superficial to explain the shift of Symbol Elaboration from DSI to EST as being due to the test's number content, with the consequent interpretation of DSI, as found, to depend heavily upon words as stimuli, and EST as depending upon numbers. This hypothesis must be rejected since both factors are defined by both word and number tests. Symbol Elaboration is composed of simple algebraic equations and the algebraic content of Judging Mathematical Expressions may have pulled it toward EST, where the latter test naturally belongs. The communality of these two tests can be attributed to a variable of mathematical sophistication.

Word-Pair Revisions, formerly called Limited Words, has had CSU involvement (Gershon, et al., 1963), which was explained as being due to the need for E to see the words hidden in the given pairs. With the redirection of the CSU vector away from NST tests since 1963, it appears that Limited Words' secondary variance may really have been in the direction of NST all along. The NST loading for Word-Pair Revisions indicates that in many cases E's task was a convergent one; trying a cognized or embedded word and then checking to see if a second word was possible. From the point of view of the convergent-production operation, the product is more like a transformation than an implication.

The loading of Multiple Symbolic Implications on the SEX factor implies that males performed better than females on this arithmetic test. The production of several potential implications of the printed words was involved in the previously given explanation of the DSI loading of Reading Backwards.

DMC - Divergent Production of Semantic Classes

1. Alternate Uses (DMC)	.47	(.36 NMT)
22. Multiple Grouping (DMC)	.33	(.35 CMI)

The DMC factor, semantic flexibility, emerged weakly in this analysis but the two DMC marker tests do determine this vector, nonetheless. The NMT involvement of Alternate Uses may be due to the common nature of the stimuli. All the tests loading on NMT are concerned with uses of real objects, as in Alternate Uses. Such an affiliation between Alternate Uses and NMT has not been evident before, in spite of opportunities. The connection here may be attributed to the particular population or to chance.

DMT - Divergent Production of Semantic Transformations

5. Consequences (DMT)	.56	(.32 CMI)
44. Whoppers (DMT)	.36	
31. Plot Titles (DMT)	.35	
30. Pertinent Questions (CMI)	.34	(.37 CMI)
36. Seeing Different Meanings (CMT)	.33	(.51 CMT)

The originality factor, DMT, is marked by the three tests designed for that factor. The implications involvement of Consequences was discussed under the CMI factor. Although DMU, ideational fluency, was not intentionally represented in this analysis, it seems that undesired DMU variance did not contribute to the strength of DMT. If it did, Whoppers should have a higher loading, as it was expected that Whoppers might have considerable DMU variance. The low DMT loading of Whoppers suggests that any possible DMU variance in it was not part of the common-factor solution. The marginal loadings of Pertinent Questions and Seeing Different Meanings have been discussed above.

NST - Convergent Production of Symbolic Transformations

18. Limited Word Revisions (NST)	.48	
11. Efficient Word Transformations (NST)	.37	
3. Camouflaged Words (NST)	.35	
46. Word-Pair Revisions (DSI)	.33	(.67 DSI)

The ability to produce new symbolic items of information by revising given items in fully restricted ways is strongly demonstrated in this analysis, mostly by the two new tests devised to measure it, aided by the old test, Camouflaged Words. This demonstration of the factor indicates for the first time the breadth of relationships of NST to tests and its distinctness from CSU. With a reliability estimate of .83 and a communality estimate of .51, it is possible that Efficient Word Transformations has considerable involvement in some other factor, for example, CSI.

NMT - Convergent Production of Semantic Transformations

26. New Uses (NMT)	.57	
29. Object Synthesis (NMT)	.51	
41. Useful Changes (EMT)	.43	
1. Alternate Uses (DMC)	.36	(.47 DMC)

The NMT factor, representing the ability to produce new uses for objects by redefining them in accordance with their contexts, was found to be clear and strong in this study, but its tests were still concerned only with objects and their redifinitions; not with words or ideas in general. This conclusion is forced by the fact that Daffynitions did not cohere with the two leading NMT tests, and also the fact that two tests for other factors, Useful Changes for EMT and Alternate Uses for DMC, both involving the changing of objects, was pulled onto the NMT factor.

The task in Useful Changes is to select an object that can perform a given task most adequately. It had been assumed (Hoepfner, et al., 1966) that E easily makes the necessary transformation of the objects, and that the decision of which transformed object is most adequate is the major aspect of the task. It was with this interpretation of Useful Changes that it was previously rotated to a singlet factor, separate from an NMT singlet, and was called EMT. In this analysis, where NMT and EMT are given equal opportunities to emerge, the production aspect of Useful Changes appears to be more important to the task than is evaluation, and hence its NMT factor loading. It would be of interest to see whether the 1966 factor solution could accomodate an NMT-EMT collapse to one stronger factor that would be called NMT.

EST - Evaluation of Symbolic Transformations

17. Jumbled Words (EST)	.54	
15. Judging Mathematical Expressions (EST)	.48	(.35 SEX)
8. Decoding (EST)	.40	
40. Symbol Elaboration (DSI)	.34	

EST emerged strongly as the ability to judge adequacies or correctness of symbolic substitutions and reorderings. The addition of Judging Mathematical Expressions to the list of EST tests broadens the scope of tasks that involve this factor, to include comparisons of numbers as well as words and letters. Symbol Elaboration's loading on EST may be due to two reasons. First, E must continually compare all new equations he produces with the given equation, since he knows wrong equations are not credited. The activity of making comparisons may constitute the major aspect of this test. A second was mentioned under DSI, and attributed the linkage to a hypothetical mathematical-sophistication variable in common between this test and Judging Mathematical Expressions.

EMT - Evaluation of Semantic Transformations

32. Punch Line Comparisons (EMT)	.47
16. Judging Object Adaptations (EMT)	.45

A new EMT-appearing factor is demonstrated in this analysis, laying better claim to SI ability EMT than any before. In Punch Line Comparisons two given redefinitions of cartoons are compared and in Judging Object Adaptations three transformations of given objects are compared. The redefinitions and transformations are already produced for E, and for that reason there is no convergent-production involvement.

Useful Changes, which was intended for EMT and which had appeared on a singlet factor before, now seems to involve NMT instead. It is quite similar to good EMT tests, but too much production and too little evaluation are evidently required for it to be an EMT test.

SEX

47. Sex	.63	(-.30 MST)
24. Multiple Symbolic Implications (DSI)	.38	(.41 DSI)
15. Judging Mathematical Expressions (EST)	.35	(.48 EST)

The SEX factor is led by the sex-membership variable, but helped by two mathematical tests, confirming the male superiority in such tests.

Factor Involvement in Learning

If the measure designed in this study to assess school learning does, indeed, reflect the ability complex commonly called upon in typical school-learning situations, the regression analysis reported in Table 6 gives indications concerning which underlying basic intellectual aptitudes are involved and their relative importance in that kind of learning.

Not unexpectedly, the CMU factor, verbal comprehension, appeared as the major predictor of learning performance. Since CMU has long been known to be the major component of ordinary tests of reading comprehension, it might also be a strong component of reading-and-memory tests. It may be recalled that the Studying and Remembering tests were written so that vocabulary, as such, would not unduly challenge these gifted high-school students. If this had not been achieved, and difficult vocabulary had been utilized, a much larger CMU involvement would have been expected.

The second strongest predictor was the score for MMT, memory for semantic transformations. This should mean that the Es first cognized such transformations while reading the paragraphs and that such cognitions became fixed sufficiently to function in taking the immediately following multiple-choice test. It can be hypothesized that while reading E sees or produces some changes in knowledge previously held with regard to the contents of the paragraphs or changes occur during second looks at the information, as he reads further or as he comes back to the same sentences for rechecking. These transformations are stored as transformations along with units, classes, and so on, and they somehow function so as to help E to answer the test items correctly. He may remember certain units because he remembers transformations in which they were involved, for example. The fact that ability CMT is also relevant in the test of retention supports the hypothesis that E learned transformations. The hypothesis that E cognizes some transformations during the process of answering the multiple-choice items cannot be ruled out. His reading of the alternative answers to items may suggest how he was wrong in his reading and that he saw what kind of revision must be made in his remembered information. Here, also, CMT would be relevant.

It was stated earlier that Kleuver (1968) had also found MMT strongly related to reading comprehension at the fourth-grade level. In ordinary reading-comprehension tests E can refer back to the reading material as much as he wishes. This condition should present even more opportunities for revisions of conceptions, but it would require retention over shorter time lapses than in the reading-memory type of test used in this study. At any rate, the finding in this study confirms that of Kleuver.

A pair of similar abilities that could not have been expected to show relevance in reading and remembering was made up of DST and EST. The symbolic nature of both abilities will have to be attributed to the fact that two of the three selections for reading included numerical values--weights of annually produced proteins and numbers of stock-market investors. The relevance of divergent-production and evaluation operations suggest the hypothesis that some trial-and-error behavior was going on, probably during the taking of the memory test. It is suggested that much guessing went on concerning the numerical quantities (DST) and self checking with regard to those guesses (EST). Why transformations rather than some other product? This is not so easy to answer. It is not very likely that this is because every new guess E makes is a revision of a number and the revision is evaluated. In similar circumstances it is more likely that it is the new product, here a symbolic unit, that is evaluated. But we have no basis for ruling out this suggested hypothesis; that it is the change that is evaluated, hence the involvement of EST.

The involvement of DMC in the reading-memory test is more reasonable, at least because of its semantic aspect. Divergent production invariably involves suggested alternatives, and there is opportunity for this either during the reading or during the test on the reading material. We cannot be sure that there was no relevance for abilities CMC and MMC, so as to rule out the possibility that the divergent activity occurred during the reading. The alternatives produced are in the form of classes. DMC means flexibility with regard to classes; readiness to reclassify ideas. The need for producing alternative classes in the criterion test is not obvious, but it might pay to follow this up with alternative hypotheses.

The involvement of NMT is also puzzling. This ability applies to producing a transformation in a conception to fulfill a particular need. Only one logically pertinent transformation will do to solve the problem. It may be that E remembers enough facts from the reading so that for a particular fact demanded by the test item, some other remembered fact, properly revised, can point to the needed answer. It is sometimes recognized by teachers that a student selects the right alternative answer "by reasoning" rather than from memory of the answer. The "reasoning" may involve some kind of transformation.

An important general point that is demonstrated by the collection of SI-ability scores that contribute significantly to prediction of the reading-memory criterion is that only one of them--CMU-- is known to be covered in general academic-aptitude tests. The others, MMT, CMT, DST, EST, DMC, and NMT, are mostly from the category of transformation abilities, but that category was greatly favored in the selection of abilities for this investigation. It may be pointed out, however, that other abilities not contributing significantly included: CSU, CMI, MSI, and DSI. It is interesting that none of the implications abilities proved to be relevant, whereas they are the clearest cases having to do with what was formerly called the formation of "associations," also the memory and production of "associations." In this connection it can be said that the multiple-choice items were written without any particular attempt to stress a paired-associate type of learning. It is unfair to exclude possibilities for other implication abilities to show relationships to learning, of course. There were other transformation abilities that also failed to show relevance, including: CST, MST, DMT, NST, and EMT.

But there are still other SI abilities, not included in this study, that might well show some added relevance for predicting reading and remembering performance. Memory abilities other than MMT might be suggested first--memory for units, classes, relations, systems, and implications. With all the

relevant abilities brought into the regression equation, the multiple correlation should be expected to go well above the obtained .58. Note that the pattern of relevant abilities should depend also upon the nature of the reading material's content and upon the nature of the learning score employed. If the material used in this study had contained no numerical facts, for example, the abilities DST and EST might have been irrelevant.

DISCUSSION

The Abilities and Their Tests

The rigorous attempt to lend empirical support to the SI model, by simultaneously investigating 10 parallel factors of transformations which could possibly be difficult to separate, appears to have been quite successful. For the first time, 10 of the 20 hypothesized abilities concerned with transformations have been simultaneously separated and identified. The great majority of the tests designed to measure transformation abilities and the reference factors had their major correlations with the respective factors for which they were hypothesized. Only three of the 46 test variables were loaded primarily upon factors other than those for which they were hypothesized.

The Cognition Abilities

Many of the important theoretical problems this study was designed to investigate involved five cognition factors: CSU, CST, CMU, CMT, and CMI. Twenty-two tests defined the five factors, primarily or secondarily, of which 16 were designed for cognition, two for memory, three for divergent production, and one for convergent production. It was of particular interest that evaluation tests played no part in the demonstration of their parallel cognition factors, a circumstance that has not always prevailed.

The identification of the CST factor for the first time, distinctly separate from the CSU and NST factors with which confusion of tests might be expected, completed the demonstration of all symbolic-cognition factors in the SI model. So far as this analysis goes, the CST factor appears limited to tests that ask E to see reorganizations of letters in words. As such, it would seem to be an excellent candidate for predicting success in stenographic and proofreading occupations. Whether or not numerical tests can be devised to reflect the CST aptitude, while not reflecting some other ability also indicated by number tests, remains to be determined. Theoretically this should be possible.

In the semantic area, the clear separation of CMT and CMI adds confidence to the demonstration of all the semantic-cognition factors. While CMT is concerned with the recognition of revisions of ideas, CMI is concerned with their logical implications. Tests that stress one of the abilities to the exclusion of the other can reasonably be expected to load on only one of the factors. Tests of CMT in the past have characteristically not met the requirement of non-involvement with CMI.

The rather basic cognition factors for units, CSU and CMU, were not involved in any of the test lists for other cognition factors, nor for noncognition factors in this analysis, with but one minor exception.

The Memory Abilities

Eight tests were employed to measure the three memory factors in this study. All eight of the tests were loaded on their hypothesized factors, and only one was not univocal. The three memory factors were aided in their emergence by secondary loadings of one cognition test, and the sex variable. In addition to the replication of the memory factors and the improvement of our knowledge about them, their demonstration in this analysis served two important purposes.

Two previous studies (Brown, et al., 1968; Tenopyr, et al., 1966) found two sets of six memory factors, semantic and symbolic, respectively. There was no evidence in either of those studies that parallel memory factors of different content could be separated with equal success. Dunham, et al., (1966) had demonstrated the separation of MSC and MMC. The separation of MMT from MST in this study adds support to the SI model's content separation in the operation of memory.

The reconfirmation that Numerical Operations and Number-Letter Association go together on the MSI factor strengthens confidence that, whatever other aptitude variances comprise numerical facility, simple tests of it strongly involve the retention of symbolic implications (associations). Addition and subtraction facts, as E. L. Thorndike called them, also multiplication and division facts, are committed to memory by the young learner as arbitrary connections, or implications, and the problems are solved by reference to those implications in the memory store.

The Divergent-Production Abilities

Of the 11 tests designed to measure the divergent-production factors, 10 had major loadings on their respective hypothesized factors. The eleventh, Symbol Elaboration, shifted its only significant loading onto the evaluation factor EST. Four congition tests helped in the location of the divergent-production factor axes. It was noted earlier that two of them called for multiple responses, which may give them a divergent-production feature.

The major concern within the divergent-production area was the identification of DST for the first time, and its separation from the parallel factor, DSI. The separation of parallel factors in this operation category was similar to that for the cognition factors. DST is concerned with the varied production of symbol rearrangements, or other revisions, within words, while DSI theoretically involves producing alternative items of symbolic information suggested by given information. Some of the tests for both factors had loadings also on other factors, but none of those other factors were in common to the two lists of tests.

The evidence for DMC was not very strong, probably due to the fact that two short tests served as its only markers. The three originality tests were loaded on DMT, but not as highly as was expected.

The Convergent-Production Abilities

The two convergent-production factors, NST and NMT, were marked by five of the six tests hypothesized for them. The loss of Daffynitions to the parallel cognition factor was accepted as a meaningful demonstration of that test's genuine factor relevance. The convergent-production factors were aided by two divergent-production tests and one evaluation test, but were, on the whole, very well defined.

The nature of NST was more strongly delineated as involving the general rearrangement of symbols within wholes in order to meet some specified criterion. NMT is still marked by tests restricted to the reinterpretation of objects, but the improved tests offer the possibility of much better measurement of the ability.

The Evaluation Abilities

Of the six tests designed to measure the two evaluation factors, all but one were loaded on their hypothesized factors. One divergent-production test aided in the location of EST. EST was identified as previously, but its relevant test list was broadened to include comparisons of numbers.

The EMT factor is essentially a new factor that fits better into the EMT place of the SI model. There is an obvious need for more reliable instruments to measure this construct, however. The apparent requirement for EMT tests is that they must present the stimulus and its transformation, so that the transformation can be evaluated for adequacy without the necessity of producing it or of judging the transform.

Factors Involved in School Learning

The finding that 7 of the 16 aptitude factors investigated in this study have, in combination, statistically significant relationships with the measure of school learning, illustrates quite clearly the inherent shortcomings of currently used educational prognostic devices. Since these latter tests do not assess six of these relevant abilities we can see interesting possibilities for improving prediction of learning achievement. It should be noted, however, that the multiple-regression analysis presented here lacks the benefit of a cross validation.

More speculatively, we may guess what the implication of findings would be had a larger number of factors been studied in relation to school learning. Familiarity with the SI model suggests that factors such as CMS, MMU, MMS, MMI, and EMU should contribute significantly to prediction. This speculation only adds to the impact of the suggestion previously made regarding the improvement of prediction in education.

Recommended Factor Tests

A goal subordinate to the confirmation and identification of the transformation abilities and the investigation of their relationships to school learning, was to develop reliable and factorially univocal tests for the factors under primary consideration. Those tests for which the analysis has revealed relatively high reliability and relative univocality of factor saturation can be recommended as tests to be employed in further research, and possibly as candidates for use in applied areas. The tests considered as the best measures of their factors are listed below.

CST - Finding Letter Transformations
Reading Confused Words

CMT - Seeing Different Meanings
Daffynitions

MST - Memory for Misspelling
Memory for Word Transformations
Memory for Hidden Transformations

MMT - Homonyms

DST - Multiple Letter Changes
Hidden Word Production

DSI - Word-Pair Revisions

NST - Limited Word Revisions

NMT - New Uses
Object Synthesis

EST - Jumbled Words
Judging Mathematical Expressions

EMT - Punch Line Comparisons
Judging Object Adaptations

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APPENDIX

DESCRIPTION OF TESTS [1].

1. Alternate Uses - DMC03D (SPS). List as many as six uses for an object, other than the common use which is stated.

Sample Item: Given: A NEWSPAPER (used for reading)

a. start a fire
b. wrap garbage
c. swat flies
d. stuffing to pack boxes

Score: Number of possible, different uses listed.
Parts: 2; items per part: 3; working time: 8 minutes.

2. Apparatus Test - CMI03A. Suggest two improvements for common appliances and useful objects.

Sample Item: Given: TELEPHONE

a. A device that tells you who is calling before you answer.
b. A device into which you can say the number instead of dialing.

Score: Number of acceptable responses showing sensitivity to shortcomings or awareness of desirable improvements.
Parts: 1; items per part: 10; working time: 6 minutes.

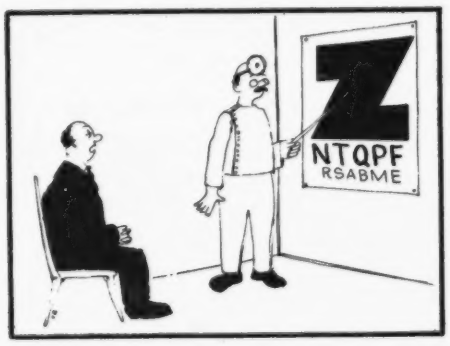
3. Camouflaged Words - NST01A. Find within a meaningful sentence a group of consecutive letters that, in the given order, spell the name of a sport or game.

Sample Item: COWARDICE IS NOT A SOLDIERLY ATTRIBUTE Answer: DICE (circled)

Score: Number of correct responses, one camouflaged word per item.
Parts: 1; items per part: 15; working time: 6 minutes.

4. Cartoons - CMT03A. Write clever punch lines for given cartoon pictures.

Sample Item:



Patient: I'd say "z", but it's only a wild guess.

Score: One point for each punch line that indicates a reinterpretation of the pictured situation, an unexpected interpretation, a play on words, or an understatement of the problem.
Parts: 3; items per part: 5; working time: 12 minutes.

5. Consequences - DMT03C (SPS). List many different results that would be associated with a new and unusual situation.

Sample Item: What would be the results if people no longer needed, or wanted sleep?

1. Get more work done
2. Alarm clocks not necessary
3. No need for lullaby song books
4. Sleeping pills no longer needed

Score: Number of responses that indicate indirect results or unusual adaptations to the given situations.
Parts: 3; items per part: 1; working time: 6 minutes.

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[1] The code symbol immediately following each test name indicates the hypothesized factor content of the test at the stage of test construction. The additional trigram (SPS) for some of the tests indicates that the test is copyrighted by Sheridan Psychological Services, Inc., Beverly Hills, California, and was adapted with permission.

6. Correct Spelling - CSU07A (SPS). State whether each word presented is spelled correctly.

Sample Items:
I. experience
II. thier
III. seperate

Answers: I. - correct; II. and III. - incorrect.

Score: Number of items right minus number wrong.
Parts: 2; items per part: 30; working time: 6 minutes.

7. Daffynitions - NMT04A. Redefine given words by writing sentences or phrases to indicate the new (Malaprop-like) meaning.

Sample Items:
TREE I have tree new pencils.
DECIDE Decide of de barn is red.

Score: One point for each word that is redefined to be different from its ordinary meaning, yet reasonable in terms of spelling or sound. Parts: 2; items per part: 15 and 16; working time: 10 minutes.

8. Decoding - EST01B. Choose the word that would be easier to decode if coded. The code is based upon probabilities of letter occurrences and is a highly ambiguous one.

Code:
All double letters (oo, gg, etc.) are 1.
All pairs of vowels (ea, ou, etc.) are 2.
All pairs of consonants (bl, sh, etc.) are 3.
All vowels (a, e, i, o, u, y) are 4.
All consonants (b, g, p, etc.) are 5.

Sample Items:
A. call
B. miss
C. both words

A. strong
B. trusty
C. both words

Answers: C, B.

Score: Number of items right minus one-half the number wrong.
Parts: 2; items per part: 15; working time: 8 minutes.

9. Disemvowelled Words - CSU04B. Recognize familiar words with dashes in place of vowels, then complete the words by writing the vowels.

Sample Item:
m u t i l a t e

Score: Number of correctly completed words; minor spelling errors not discredited.
Parts: 1; items per part: 25; working time: 5 minutes.

10. Double Meanings - MMT01B. Recognize pairs of underscored words in sentences that were or were not presented as words with double meanings in sentences previously studied.

Sample Study Item:
She carried the food in a paper bag.
The hunter planned to bag a deer.

Sample Test Items:
1. John took his lunch in a sack.
Mother wants to obtain a new chair.

2. He was asked to name the letter after S.
The beverage can be hot or cold.

Answers: 1. - same meaning; 2. - different meaning.

Score: Number of items right minus number wrong.

Parts: 2; items per study page: 10; items per test page: 20; working time: 8 minutes.

11. Efficient Word Transformations - NST04A. Combine (overlap) four given words so that as few letters as possible are used.

Sample Item: Given: ENTER LOOP OPEN POLO

POLOOPENTER

Score: Number of letter combinations that use fewest possible letters.
Parts: 2; items per part: 10; working time: 10 minutes.

12. Finding Letter Transformations - CST01A. Describe the changes in letters found in each pair of words.

Sample Items:
I. maneuver - manuever u and e interchanged
II. citizen - citezin i and e switched
III. calculus - calolus cu dropped; o added

Score: Number of correctly reported letter changes. Parts: 2; items per part: 20; working time: 8 minutes.

13. Hidden Word Production - DST01A. Write sentences or phrases that contain given words, either split or embedded within the sentence or phrase. A given word may not be split or embedded the same way more than once.

Sample Item: FORMER
For merely one dollar
Inform Brors
Yourself or Mervin

Score: Number of sentences or phrases containing differently split or embedded given words.
Parts: 3; items per part: 5; working time: 15 minutes.

14. Homonyms - MMT02B. Recognize a definition that matches the definition of the "other element" in a pair of previously studied homonyms.

Sample Study Item: There is a hole in the wall.
He ate the whole pie.

Answer: C

Sample Test Item: ENTIRE

A. Nut
B. Ship
C. Hollow space
D. Operation

Score: Number of items right minus one-third the number wrong.
Parts: 2; items per part: 10; working time: 5 minutes.

15. Judging Mathematical Expressions - EST04A. Judge whether or not mathematical expressions are equivalent alternatives of a given mathematical expression.

Given Expression:

$$\frac{(2p + 4q)}{8r}$$

Sample Items:

1. $\frac{2(p + 2q)}{8r}$
2. $\frac{4(\frac{p}{2} + q)}{8r}$
3. $\frac{4(p + q)}{8r}$

Answers: 1. yes; 2. yes; 3. no

Score: Number of items right minus number wrong. Parts: 2; items per part: 15; working time: 8 minutes.

16. Judging Object Adaptations - EMT06A. Select activities that illustrate the most unusual, ingenious, or clever possible uses of given objects.

Sample Item: Given Object: TELEPHONE

Activities:
A. get help in an emergency
B. pound a nail
C. keep a dog near a tree

Answer: C.

Score: Number of items right minus one-half the number wrong.
Parts: 2; items per part: 15, 14; working time: 7 1/2 minutes.

17. Jumbled Words - EST03A. Judge whether or not words could be made by mixing the letters of a given word.

Sample Items: start (given word)

I. stare
II. starts
III. tarts

Answers: I. - no; II. - no; III. - yes.

Score: Number of items right minus number wrong.
Parts: 2; items per part: 25; working time: 4 minutes.

18. Limited Word Revisions - NST05A. Make a new word, using all the letters of a given word. Do not use the last letter of the given word as the first letter of the new word.

Sample Items:

GIVEN WORDS	NEW WORDS
Tale	late
Scart	carts
Elbow	below

Score: Number of new words made.
Parts: 2; items per part: 30; working time: 8 minutes.

19. Memory For Hidden Transformations - MST01B. Having studied a page presenting sentences in each of which a word, made by taking the last letter(s) from one word and first letter(s) from the following word(s), are marked, say whether the same word appearing in a new sentence on a test page is formed the same way.

Sample Study Sentences: Don't leap in before you look.
You must not burden the teacher.

Sample Test Sentences: 1. They load entire trucks.
2. He will stop in the evening.

Answers: 1. - different; 2. - same.

Score: Number of items right minus number wrong. Parts: 2; items per part: 12; working time: 6 minutes.

20. Memory For Misspelling - MST02B. Having studied a page presenting a list of common words, each misspelled, after the correctly spelled word on a test page, write the word misspelled as it was on the study page.

Sample Items:

Given Misspelled Study Words:	Test Words:
boan	1. kettle kettal
kettal	2. bone boan

Score: Number of words correctly misspelled. Parts: 2; items per part: 15; working time: 6 minutes.

21. Memory For Word Transformations - MST03A. Having studied a page containing groups of letters, each of which is divided to form two words, and which could be divided in another way to form two different words, mark whether each group of letters on a test page is divided in the same way as it was on the study page.

Sample Items:	STUDY WORDS	TEST WORDS	Answers: 1. - different; 2. - same.
	BIND/ARE	1. EAR/NICE	Score: Number of items right minus number wrong.
	EARN/ICE	2. BIND/ARE	Parts: 2; items per part: 15; working time: 4 1/2 minutes.

22. Multiple Grouping - DMC02D. Arrange given words into several different meaningful groups.

Sample Item:

GIVEN WORDS	GROUPS
1. arrow	Class A: 1, 2, 5, 7
2. bee	Class B: 3, 4, 6
3. crocodile	Class C: 2, 3, 4, 7
4. fish	Class D: 3, 4, 5, 7
5. kite	
6. sailboat	Score: Number of acceptable classes produced.
7. sparrow	Parts: 1; items per part: 2; working time: 4 minutes.

23. Multiple Letter Changes - DST02A. Change any two letters in given 5-letter words to make new 5-letter words. Change any two or three letters in given 6-letter words to make new 6-letter words. Any letters may be used to make new real words.

Sample Items:

GIVEN (Change any 2 letters)	FOLDER (Change any 2 or 3 letters)
liver	finder
lives	silver
gavel	fueler
seven	softer

Score: Number of different acceptable words produced.

Parts: 2; items per part: 3: working time: 8 minutes.

24. Multiple Symbolic Implications - DSI03A. Make different combinations of numbers, involving addition, multiplication, or division, that yield given numbers as answers.

Sample Items:

ADDITION	MULTIPLICATION	DIVISION
1. 2 + 2 + 6 = 10	1. 2 x 3 x 10 = 60	1. 12 ÷ 3 ÷ 2 = 2
2. 3 + 3 + 4 = 10	2. 2 x 2 x 15 = 60	2. 30 ÷ 5 ÷ 3 = 2
3. 2 + 3 + 5 = 10	3. 2 x 5 x 6 = 60	3. 20 ÷ 5 ÷ 2 = 2

Score: Number of different and correct combinations produced.
Parts: 2; items per part: 3; working time: 10 minutes.

25. Multiple Word Extractions - DST03A. Make several little words from given big words so that all letters remain in consecutive order, each little word has at least two letters, and no little word is a syllable of a given big word.

Sample Item: e gal i tar i an tick ing

1. it
2. ant
3. anti
4. king
5. antic

Score: Number of acceptable little words produced.

Parts: 2; items per part: 4; working time: 8 minutes.

26. New Uses - NMT05A. Make objects in given pictures serve new uses by taking a part or combination of parts of objects to solve given problems.

Sample Item:

to make a small kite picture frame and curtain

as an anchor for a small boat base of chair

to make a Chinese checker board wall paneling

Score: Number of acceptable objects or their parts used. Parts: 3; items per part: 10; working time: 9 minutes.

27. Number-Letter Association - MSI08A. Having studied a page presenting two-digit numbers paired with single letters, write on a test page the letter that was studied as paired with a given number.

SAMPLE STUDY PAGE	SAMPLE TEST PAGE
88 - U	I. 67 K
67 - K	II. 88 U

Score: Number of correctly recalled letter associates.
Parts: 2; items per part: 13; working time: 7 minutes.

28. Numerical Operations - MSI01B (SPS). Do addition, subtraction and multiplication problems rapidly.

Sample Items:

ADD

28		77
65		83
52		12
=	145	=
=	154	=
=	155	=
=	172	=
=	174	=
=	182	=

SUBTRACT

94		74
−55		−38
=	27	=
=	29	=
=	36	=
=	39	=
=	46	=
=	47	=

MULTIPLY

94		52
X 5		X 9
=	358	=
=	380	=
=	458	=
=	460	=
=	468	=
=	470	=

Score: Number of items right minus one-fifth number wrong.

Parts: 2; items per part: 36; working time: 4 minutes.

29. Object Synthesis - NMT02A. Write new things that could be made by combining two given objects.

Sample Items: I. Nail cane paper picker

II. Volleyball steel spring punching bag

Score: Number of acceptable new things made from pairs of objects.
Parts: 2; items per part: 12; working time: 8 minutes.

30. Pertinent Questions - CMI02C (SPS). Write as many as four questions that should be considered in making decisions in each given problem situation.

Sample Item: Some teen-agers want to build a clubhouse. Two vacant lots are available. What questions must be considered in making a choice between the two lots?

a. Which lot is nearest to where the students live?
b. Is anyone planning to build a house on one of the lots?
c. Which lot is large enough for their clubhouse?
d. Which lot has friendly neighbors?

Score: Number of questions or problems stated that indicate awareness of potential problems in the situation. Parts: 1; items per part: 4; working time: 6 minutes.

31. Plot Titles - DMT01G (SPS). Write as many appropriate titles as you can for short plots of stories.

Score: Number of titles that are especially succinct, remotely but cleverly related to the plot, or indicative of a reinterpretation of the plot by virtue of new emphasis. Parts: 2; items per part: 1; working time: 6 minutes.

32. Punch-Line Comparisons - EMT07A. Judge which punch line of a pair beneath a cartoon is more unexpected and clever.

Sample Item:

1. A. My hat is old enough to watch itself.
   B. I've watched it so long it's last year's model.
2. A. You thought I wouldn't see the bug in my soup.
   B. My hat's alright, but where is my steak?

Answer: 1. - A; 2. - A.

Score: Number of items right minus number wrong.

Parts: 3; items per part: 8, 9, 10; working time: 7 minutes.

33. Reading Backwards - CST02A. Quickly read simple statements that are printed backwards, and then answer each question or do what the statement tells you to do.

Sample Items:
1. elcric a ward ___O___
2. sthgie eerht etirw ___888___
3. nezod a ni selppa ynam woh ___12___

Score: Number of correct responses.

Parts: 2; items per part: 15; working time: 6 minutes.

34. Reading Confused Words - CST03A. Write down what given confused words, with sounds mixed up as in "bloopers," should have been.

Sample Items:
I. redboom ___bedroom___
II. static airs ___attic stairs___
III. pots of wower ___watts of power___

Score: Number of correct translations of confused word sets.
Parts: 2; items per part: 10; working time: 6 minutes.

35. Remembering Puns - MMT03A. Recall the appropriate word corresponding to a pun word presented on a previously studied page.

Sample Study Item: A bird-loving bartender was arrested for contributing to the delinquency of a mynah.

Sample Test Item:

PUN WORD	PUN MEANING
MYNAH	minor

Score: Number of correctly recalled pun meanings. Parts: 2; item per part: 15; working time: 6 minutes.

36. Seeing Different Meanings - CMT05A. Write as many as four different meanings for each given word.

SAMPLE WORD	POSSIBLE MEANINGS
Scale	a. balance for weighing
	b. fish scales
	c. consecutive musical tones
	d. scale the wall

Score: Number of different acceptable meanings listed.
Parts: 2; items per part: 8; working time: 10 minutes.

37. Seeing Letter Changes - CST04A. Match one letter change within a pair of words to another change of the same kind in another pair of words.

Sample Items:

1. cad - cod
2. cry - pry
3. tin - nit
4. aye - yea

A. die - lie
B. tan - ant
C. set - sit
D. cat - car
E. nap - pan

Answers: 1. C; 2. A; 3. E; 4. B.

Score: Number of items right minus one-fourth the number wrong.
Parts: 2; items per part: 16; working time: 8 minutes.

38. Seeing Problems - CMI04B (SPS). Write as many as three problems for each given object.

Sample Item: Given Object: CANDLE

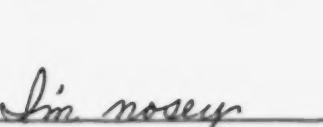
1. How to light it
2. Keeping it from falling over
3. How long will it burn?

Score: Total number of relevant implied problems listed.
Parts: 1; items per part: 9; working time: 5 minutes.

39. Seeing Puzzle Meanings - CMT04A. Under each given rebus-like puzzle, write the sentence or phrase that means the same as the puzzle.

Sample Items: I. T 4 II

tea for two

II.  'M → {, +E

I'm nosey

Score: Number of correct puzzle translations.
Parts: 2; items per part: 10; working time: 6 minutes.

40. Symbol Elaboration - DSI01B. Write as many as six new equations derived from given simple equations involving numbers and letters.

Sample Item: GIVEN: B - C = D
Z = 2A + D

NEW EQUATIONS:

D = Z - 2A
B - C = Z - 2A
2 = (Z - D) ÷ A
Z = 2A + B - C
B - Z = C - 2A

Score: Number of correctly derived equations produced.
Parts: 2; items per part: 3; working time: 8 minutes.

41. Useful Changes - EMT03B. Choose one of three objects that could perform a given task most adequately.

Sample Item: TO SLICE CHEESE

A. guitar
B. plate
C. paper clip

Answer: A.

Score: Number of items right minus one-half the number wrong.
Parts: 2; items per part: 10, 9; working time: 6 minutes.

42. Verbal Comprehension - CMU02D (SPS). Choose the alternative word that means about the same as the given word.

Sample Item: Given Word: TO REAP

A. to flatter
B. to harvest
C. to refer
D. to release
E. to repose

Answer: B.

Score: Number of items right minus one-fourth the number wrong.
Parts: 1; items per part: 24; working time: 4 minutes.

43. Verbal-Picture Translation - CMT06A. Translate verbal descriptions of pictures into the words or phrases they describe.

Sample Items:

A piece of furniture copying notes. writing desk

A lawn that jumps about on one foot. grasshopper

A whip slashing across the letter "I". eyelash

Score: Number of correct translations. Parts: 2; items per part: 15; working time: 8 minutes.

44. Whoppers - DMT05A. List many different unusual things a compulsive liar claimed to see as she visited different places.

Sample Item:

Tella Fibb went to an AUTO SHOW, list many different unusual things she claimed to see.

square tires

glass cars

Score: Number of appropriate responses that are unusual, impossible, self-contradictory, or unlikely.
Parts: 3; items per part: 1; working time: 9 minutes.

45. Word Completion - CMU01B. Write a word or short phrase to define each given word.

Sample Item:

COURAGEOUS to be brave

Score: Number of acceptable definitions. Parts: 1; items per part: 20; working time: 5 minutes.

46. Word-Pair Revisions - DSI04A. Make new pairs of words from given pairs by combining the letters differently according to given rules.

Sample Item:

Given Pair: HIS NOT

New Pairs:

1. SIN HOT
2. HIS TON
3. THIS NO

Score: Number of acceptable new pairs produced. Parts: 2; items per part: 4; working time: 10 minutes.

47. Sex. Females were assigned the value of 0; males the value of 1.

48. Studying and Remembering. Learn and remember material on one page so that questions about it may be answered on the next page with the study material out of sight.

Three parts covered the following subjects: Proteins As Food, Drugs And Behavior, and Trends In The Stock Market.

Score: Number of items right minus one-third the number wrong.
Parts: 3; items per part: 10; study time per part: 3 1/2 minutes: test time per part: 2 minutes.